# Physical Sciences

## Constituents and Structures

### Universe

The universe **contains everything** that exists including the Earth, planets, stars, space, and galaxies. This includes all matter, energy, and even time.

No one knows for sure just **how big** the universe is. It could be infinitely large. Scientists, however, measure the size of the universe by what they can see. They call this the "observable universe (or the "**Hubble Volume**")". It is the spherical region, about 90 billion light-years in diameter, that is centered on any given observer. This is the only part of the universe in which light has had time to reach the observer in the 13.8 billion years since the universe began.

One of the interesting things about the universe is that it is currently **expanding**. It's growing larger and larger all the time. Not only is it growing larger, but the edge of the universe is expanding at a faster and faster rate. Scientists think that the edge of the universe is expanding faster than the speed of light.

Even though the Earth seems really big to us, it's actually a very tiny part of the universe. The Sun has a mass of 330,000 times the Earth. The Sun is just one star in the Milky Way galaxy that contains over 300 billion stars and scientists estimate that there are over 170 billion galaxies in the universe! However, most of the universe is what we think of as empty space. All the atoms together only make up around four percent of the universe. The majority of the universe consists of something scientists call **dark matter and dark energy**.

Dark matter - Scientists aren't sure exactly what dark matter is, but they believe that it exists due to experiments. Dark matter gets its name because it cannot be seen with any type of instrument that we have today. Around 27% of the universe is made up of dark matter.

Dark energy - Dark energy is something that scientists believe fills all space. It turns out that "empty space" is more than just nothing but is really dark energy. The theory of dark energy helps scientists to explain why the universe is expanding. Around 68% of the universe is dark energy.

Scientists think that the universe began between 13 and 14 billion years ago with the start of a massive explosion called the Big Bang.

**BBT**- The Big Bang Theory is the leading explanation about how the universe began. At its simplest, it says the universe as we know it started with an infinitely hot, infinitely dense singularity, then inflated — first at unimaginable speed, and then at a more measurable rate — over the next 13.8 billion years to the cosmos that we know today.

Because current instruments don't allow astronomers to literally peer back at the universe's birth, much of what we understand about the Big Bang Theory comes from mathematical formulas and models. Astronomers can, however, see the "echo" of the expansion through a phenomenon known as the **cosmic microwave background**.

While the majority of the astronomical community accepts the theory, there are some theorists who have alternative explanations besides the Big Bang — such as eternal inflation or an oscillating universe.

One alternative theory is the **Steady State universe**. An early rival to the Big Bang theory, Steady State posits continuous creation of matter throughout the universe to explain its apparent expansion. This type of universe would be infinite, with no beginning or end. However, a mountain of evidence found since the mid-1960s indicates that this theory is not correct.

Another alternative is the **Eternal Inflation theory**. After the Big Bang, the universe expanded rapidly during a brief period called inflation. The Eternal Inflation theory posits that inflation never stopped, and has been going on for an infinite length of time. Somewhere, even now, new universes are coming into existence in a vast complex called the multiverse. Those many universes could have different physical laws.

**The Oscillating model** of the universe involved an endless series of Big Bangs, followed by Big Crunches that restarted the cycle, endlessly. The modern cyclic model involves colliding "branes" (a "membrane" within a higher-dimensional volume called the "bulk").

Implications found in **quantum gravity** and **string theory** tantalizingly suggest a universe that is in reality nothing like how it appears to human observers. It may actually be a flat hologram projected onto the surface of a sphere, for example. Or it could be a completely digital simulation running in a vast computer.

**Interesting Facts**

* Distant galaxies are constantly moving further and further away from us as the universe expands.
* Every galaxy in the universe is moving away from every other galaxy. There is no center to the universe.
* Albert Einstein said that the shape of the universe was open, closed, or flat. Many scientists today think that the universe is flat.
* The universe appears to be cooling and may eventually freeze.
* Large empty spaces in the universe are called voids.
* The most abundant element in the universe is hydrogen. The second most abundant element is helium.

#### Stars

Stars are giant spheres of superhot gas made up mostly of hydrogen and helium. Stars get so hot by burning hydrogen into helium in a process called nuclear fusion. This is what makes them so hot and bright. Our Sun is a star.

**Birth** - Stars start out in giant clouds of dust called nebulae. Gravity forces the dust to bunch together. As more and more dust bunches up, gravity gets stronger and it starts to get hot and becomes a protostar. Once the center gets hot enough, nuclear fusion will begin and a young star is born. **Main Sequence Star** - Once a star, it will continue to burn energy and glow for billions of years. This is the state of the star for the majority of its life and is called the "main sequence". During this time a balance is met between gravity wanting to shrink the star and heat wanting to make it grow bigger. The star will remain this way until it runs out of hydrogen. **Red Giant** - When the hydrogen runs out, the outside of the star expands and it becomes a red giant. **Collapse** - Eventually the core of the star will start to make iron. This will cause the star to collapse. What happens to the star next depends on how much mass it had (how big it was). The average star will become a white dwarf star. Larger stars will create a huge nuclear explosion called a supernova. After the supernova it may become a black hole or a neutron star.

There are many different types of stars. Stars that are in their main sequence (normal stars) are categorized by their color. The smallest stars are red and don't give off much of a glow. Medium size stars are yellow, like the Sun. The largest stars are blue and are hugely bright. The larger the main sequence star, the hotter and brighter they are.

**Dwarfs** - Smaller stars are called dwarf stars. Red and yellow stars are generally called dwarfs. A brown dwarf is one that never quite got large enough for nuclear fusion to occur. A white dwarf is the remnants of the collapse of a red giant star. **Giants** - Giant stars may be main sequence stars like a blue giant, or stars that are expanding like red giants. Some supergiant stars are as big as the entire Solar System! **Neutrons** - A neutron star is created from the collapse of a giant star. It's very tiny, but very dense.

**Fun facts**

* Most of the stars in the universe are red dwarfs.
* They twinkle because of movement in the Earth's atmosphere.
* Many stars come in pairs called binary stars. There are some groupings with up to 4 stars.
* The smaller they are the longer they live. Giant stars are bright but tend to burn out fast.
* The nearest star to Earth is Proxima Centauri. It is 4.2 light-years away, meaning you would have to travel at the speed of light for 4.2 years to get there.
* The Sun is around 4.5 billion years old.

#### Galaxies

Scientists used to think that all the stars in the universe were part of one giant grouping of stars. Then, in 1917, Thomas Wright suggested that there might be lots of different large groups of stars. A few years later this was proven by other astronomers and the idea of the galaxy became real.

A galaxy is a group of stars and other space stuff. The stars tend to spin around a center of high gravity, sort of like the planets spin around the Sun in the Solar System. Galaxies are huge and can have trillions (way bigger than billions!) of stars. As big as galaxies are, they are generally separated by large areas of empty space. There are even clusters of galaxies that are separated by even larger areas of space. Scientists think there are over 170 billion galaxies. Wow, the universe is huge!

**Milky Way**

We live in the galaxy called the Milky Way. The Milky Way is part of cluster of around 3,000 galaxies called the Local Group. The Milky Way is a **spiral shaped** galaxy and is estimated to be made up of around 300 billion stars.

**Types of Galaxies**

There are four main types of galaxies depending on their shape:

**Spiral** - The spiral galaxy has a number of long arms that are spiraling around the center. In the center of the spiral galaxy are older stars while the arms are generally made of new stars. **Barred spiral** - This type of galaxy is similar to the spiral but has a long bar in the middle with spirals coming off the ends. **Elliptical** - A mass of stars clumped together in the shape of an elliptical disc. **Irregular** - Any other shaped galaxy is generally lumped into the category of irregular. It is thought that most irregular galaxies are formed by two of the other three types of galaxies crashing into each other.

**Fun facts**

* The word galaxy comes from the Greek word for "milky".
* Some scientists think that most of the mass of a galaxy is made up of a mysterious substance called dark matter.
* It is thought that there is a massive black hole in the center of galaxies.
* The closest galaxy to the Milky Way is Andromeda, which is around 2.6 million light years away from us.
* Many galaxies are more than 100,000 light years across in distance.
* It takes over two hundred million years for the sun to orbit the center of the galaxy. This is called a galactic year.

#### Black Holes

Black holes are one of the most mysterious and powerful forces in the universe. A black hole is where gravity has become so strong that nothing around it can escape, not even light. The mass of a black hole is so compact, or dense, that the force of gravity is too strong for even light to escape.

Black holes are truly invisible. We can't actually see black holes because they don't reflect light. Scientists know they exist by observing light and objects around black holes. Strange things happen around black holes to do with quantum physics and space time. This makes them a popular subject of science fiction stories even though they are very real.

Black holes are formed when giant stars explode at the end of their lifecycle. This explosion is called a **supernova**. If the star has enough mass, it will collapse on itself down to a very small size. Due to its small size and enormous mass, the gravity will be so strong it will absorb light and become a black hole. Black holes can grow incredibly huge as they continue to absorb light and mass around them. They can even absorb other stars. Many scientists think that there are super-massive black holes at the center of galaxies.

There is a special boundary around a black hole called an event **horizon**. It is at this point that everything, even light, must go toward the black hole. There is no escape once you've crossed the event horizon!

The idea of the black hole was first proposed by two different scientists in the 18th century: **John Michell and Pierre-Simon Laplace**. In 1967, a physicist named **John Archibald Wheeler** came up with the term "black hole".

**Fun facts**

* Black holes can have the mass of several million suns.
* They don't live forever, but slowly evaporate returning their energy to the universe.
* The center of a black hole, where all its mass resides, is a point called a **singularity**.
* Black holes differ from each other in mass and their spin. Other than that, they are all very similar.
* The black holes we know about tend to fit into two size categories: "stellar" size are around the mass of one star while "supermassive" are the mass of several millions of stars. The big ones are located at the centers of large galaxies.

#### Asteroids

An asteroid is a chunk of rock and metal in outer space that is in orbit around the Sun. Asteroids vary in size from just a few feet across to hundreds of miles in diameter. Most asteroids are not round, but are lumpy and shaped like a potato. As they orbit the Sun, they tumble and spin.

**Types of Asteroids**

There are three main types of asteroids based on what type of elements make up the asteroid. The main types include carbon, stony, and metallic.

**Carbon** - Carbon asteroids are also called carbonaceous asteroids. They are made up mostly of rocks rich in the element carbon. They are very dark in color. Around 75% of all asteroids are the carbon type. **Stony** - Stony asteroids are also called salicaceous asteroids. They are made up of mostly rock and some metal. **Metallic** - Metallic asteroids are made up of mostly metals, primarily iron and nickel. They often have some small amounts of stone mixed in.

The majority of asteroids orbit the Sun in a ring called the asteroid belt. The asteroid belt is located between the planets Mars and Jupiter. You can think of it as a belt between the rocky planets and the gas planets. There are millions and millions of asteroids in the asteroid belt.

Some asteroids are so large that they are considered minor planets. The four largest asteroids are **Ceres, Vesta**, Pallas, and Hygiea.

There are other groups of asteroids outside the asteroid belt. One major group is the Trojan asteroids. Trojan asteroids share an orbit with a planet or a moon. However, they don't collide with the planet. The majority of the Trojan asteroids orbit the sun with Jupiter. Some scientists think there may be as many Trojan asteroids as there are asteroids in the belt.

Yes, not only could an asteroid hit Earth, but many asteroids have already struck Earth. These asteroids are called Near-Earth asteroids and they have orbits that cause them to pass close to the Earth. It is estimated that an asteroid larger than 10 feet across strikes the Earth around once a year. These asteroids usually explode when they hit the Earth's atmosphere and cause little damage on the Earth's surface.

**Fun facts**

* Italian astronomer Giuseppe Piazzi discovered the first asteroid, Ceres, in 1801.
* The word asteroid comes from a Greek word meaning "star shaped."
* Scientists estimate that there are over one million asteroids larger than 1km in diameter within the asteroid belt.
* The five largest asteroids make up more than 50% of the total mass of the asteroid belt.
* Some scientists have theorized that the extinction of the dinosaurs was caused by a large asteroid colliding with the Earth.

#### Comets and Meteors

Comets are lumps of ice, dust, and rock that orbit the Sun. The typical comet has a core that is a few kilometers in diameter. Comets are often called the "dirty snowballs" of the Solar System.

**Coma and Tail**

As a comet nears the Sun its ices will begin to heat up and turn into gases and plasma. These gases form a large glowing "head" around the comet that is called a "coma". As the comet speeds through space, the gases will trail behind the comet forming a tail. Because of their coma and tail, comets appear fuzzy as they near the Sun. This allows astronomers to easily determine comets from other space objects. Some comets can be seen with the naked eye as they pass by Earth.

**Orbit of a Comet**

Comets are usually divided into two groups determined by the type of orbit they have. The first type of comet is the short period comet. Short period comets have orbits of less than two hundred years. Some have very short orbits of just a few years. These types of comets originate from the Kuiper belt. The second type of comet is the long period comet. Long period comets have orbits of greater than two hundred years. Some long period comets have orbits of thousands of years. Scientists think that long period comets come from the Oort cloud.

**The Kuiper Belt**: The Kuiper belt is a region of the Solar System that lies beyond the planets and the orbit of Neptune. It is much larger than the asteroid belt. The Kuiper belt contains millions of icy objects including some larger objects like the dwarf planets Pluto and Eris.

**The Oort Cloud**: Well beyond the Kuiper belt, scientists believe there is another collection of billions of comets called the Oort cloud. This is where long orbit comets come from. The outer limit of the Oort cloud defines the outer boundary of the Solar System.

A **meteoroid** is a small piece of rock or metal that has broken off from a comet or an asteroid. Meteoroids can form from asteroids colliding or as debris from comets speeding by the Sun. Meteors are meteoroids that get pulled into Earth's atmosphere by Earth's gravity. When a meteor hits the atmosphere, it will heat up and burn with a bright streak of light called a "falling star" or a "shooting star." If several meteors occur at the same time and near the same place in the sky, it is called a **meteor shower**. A meteorite is a meteor that does not entirely burn up and makes it all the way to the ground.

**Interesting Facts**

* The Oort cloud is located about one light year from the Sun.
* One of the most famous comets is Halley's Comet. Halley's Comet has an orbit of 76 years and is visible from Earth as it passes by.
* During ancient times, people believed that the passing of a comet was an omen of doom.
* Eventually the ice will burn off of a comet and it will just be a metallic rock with no coma or tail. These comets are said to have gone "extinct".
* Millions of meteors enter the Earth's atmosphere every day. Most of them are about the size of a pebble.

#### Constellations

A constellation is a group of visible stars that form a pattern when viewed from Earth. The pattern they form may take the shape of an animal, a mythological creature, a man, a woman, or an inanimate object such as a microscope, a compass, or a crown.

The sky was divided up into 88 different constellations in 1922. This included 48 ancient constellations listed by the Greek astronomer Ptolemy as well as 40 new constellations.

The 88 different constellations divide up the entire night sky as seen from all around the Earth. Star maps are made of the brightest stars and the patterns that they make which give rise to the names of the constellations. The maps of the stars represent the position of the stars as we see them from Earth. The stars in each constellation may not be close to each other at all. Some of them are bright because they are close to Earth while others are bright because they are very large stars.

**Orion** is one of the most visible constellations. Because of its location, it can be seen throughout the world. Orion is named after a hunter from Greek mythology. Its brightest stars are Betelgeuse and Rigel. Ursa major & minor, Draco, Pegasus, The zodiac are some other constellations.

Constellations are useful because they can help people to recognize stars in the sky. By looking for patterns, the stars and locations can be much easier to spot. The constellations had uses in ancient times. They were used to help keep track of the calendar. This was very important so that people knew when to plant and harvest crops. Another important use for constellations was navigation. By finding Ursa Minor it is fairly easy to spot the North Star (Polaris). Using the height of the North Star in the sky, navigators could figure out their latitude helping ships to travel across the oceans.

#### Solar System

The term Solar System refers to the "family" of the Sun. The Sun is a star around which eight planets, among other celestial objects, revolve in orbits. This whole system of bodies is called the Solar System. The Sun is the "head" of this system.

There are many planetary systems like ours in the universe, with planets orbiting a host star. Our planetary system is named the "solar" system because our Sun is named Sol, after the Latin word for Sun, "solis," and anything related to the Sun we call "solar."

**Planets**

There are eight planets in our Solar System. Starting with the closest to the sun they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The closest four planets (Mercury, Venus, Earth, and Mars) are termed terrestrial planets, meaning they have a hard rocky surface. The furthest four planets (Jupiter, Saturn, Uranus, and Neptune) are called gas giants. These planets are much larger and their surface is composed of gas elements (mostly hydrogen).

**Other objects**

In addition to the Sun and the eight planets, there are other objects that are part of the Solar System.

Dwarf planets - Dwarf planets are objects similar to planets in the Solar System, however they are defined as not large enough to have "cleared their orbital region of other objects." Some of the dwarf planets in the Solar System include Pluto, Ceres, Eris, Haumea, and Makemake.

Comets, Asteroid Belt, Kuiper Belt and Oort Cloud

Milky way: The Solar System is part of a bigger grouping of stars called a galaxy. Our galaxy is the Milky Way. The Solar System orbits around the center of the Milky Way.

**Interesting Facts about the Solar System**

* Because Uranus and Neptune contain many "ices" such as water, methane, and ammonia they are often referred to as the "ice giants."
* Scientists estimate there are around 200 billion stars in the Milky Way galaxy.
* Pluto was once considered a full planet, but was redefined as a dwarf planet in 2006.
* About 99.85% of the mass of the Solar System is the Sun. All the other planets, asteroids, moon, etc. together make up less than 0.15% of the Solar System's mass.
* The area around the Sun where the Sun's solar wind has an influence is called the heliosphere.
* All of the planets orbit the Sun in the same counterclockwise direction.

#### Sun

**Basic info**

* Mass: 333 thousand times the mass of Earth
* Diameter: 109 times the diameter of Earth
* Temperature: 5,500 degrees C (10,000 degrees F) on the surface
* Distance from Earth: 150 million kilometers (93 million miles)
* Age: 4.5 billion years

The Sun is a yellow dwarf star at the center of our Solar System. All the planets of the Solar System orbit around the Sun. The Sun and the Solar System orbit around the center of our Galaxy, the Milky Way. Although the Sun is a relatively small star in the universe, it is huge in relation to our solar system. Even with massive gas planets like Jupiter and Saturn, the Sun contains 99.8% of all the mass in the solar system. The Sun is made up of superheated hydrogen and helium gas. Hydrogen makes up about 74% of the mass of the Sun. At the center of the Sun, hydrogen atoms, under intense pressure from gravity, undergo a process called nuclear fusion and get converted into helium atoms. The process of nuclear fusion generates a tremendous amount of heat causing radiation and eventually the sunlight that reaches the Earth.

The Sun is the main source of energy in the Solar System and life on Earth. Plants use photosynthesis in order to harness energy from the Sun. Even energy that we get from fossil fuels like oil originally came from the Sun. We can also use solar cells to convert energy from the Sun directly into electricity. In the early 1900's Albert Einstein used the formula E=MC^2 to explain how the Sun generated so much energy. In 1920 Arthur Eddington explained how the intense pressures at the center of the Sun could produce nuclear fusion and, in turn, great amounts of heat and energy.

**Interesting facts**

* The Sun is officially classified as a G-type main sequence star.
* The distance from the Sun to the Earth is used for a standard unit of measurement called the Astronomical Unit (au).
* The Sun has been worshiped as a god by many cultures including the Ancient Egyptian Sun god Ra.
* The Sun orbits the center of the Milky Way. It takes between 225 million and 250 million years for the Sun to complete its orbit through the Milky Way.
* The Sun is expected to remain stable for the next 5 billion years.
* The outer atmosphere of the Sun constantly releases a stream of charged particles called the Solar Wind.

#### Earth

**Basic info**

* Moons: 1
* Mass: 5.97 x 10^24 kg
* Diameter: 7,918 miles (12,742 km)
* Year: 365.3 Days
* Day: 23 hours and 56 minutes
* Temperature: -128.5 to +134 degrees F (-89.2 to 56.7 degrees C)
* Distance from the Sun: 3rd planet from the sun, 93 million miles (149.6 million km)
* Type of Planet: Terrestrial (has a hard rocky surface)

We obviously know more about Earth than any of the other planets. Earth is the largest of the four terrestrial planets, the other terrestrial planets being Mercury, Venus, and Mars. By terrestrial planet we mean that Earth has a hard rocky surface. The composition of the Earth is similar to other terrestrial planets in that it has an iron-core which is surrounded by a molten mantle which, in turn, is surrounded by an outer crust. We live on top of the crust.

There are many things that make Earth unique among the Solar System's planets. First, Earth is the only planet that we know of that contains life. Not only does earth contain life, but it supports millions of different forms of life. Another difference is that the Earth is mostly covered with water. Around 71% of the Earth is covered with salt water oceans. Earth is the only planet that has water in liquid form on it's surface. Also, the Earth's atmosphere is made up of mostly nitrogen and oxygen while Venus' and Mars' atmospheres are made up mostly of carbon dioxide.

The earth has seven large land masses called continents. The continents include Africa, Asia, North America, South America, Europe, Oceania, and Antarctica. It also has 5 major bodies of water called oceans including the Atlantic, Pacific, Indian, Southern, and Arctic oceans. The highest point above sea level on Earth is Mount Everest and the lowest point is the Mariana Trench.

The Earth is composed of a number of layers. On the outside is a rocky layer called the Earth's crust. Below this is the mantle followed by the outer core and the inner core. Planet Earth is made up of a number of elements. The central core of the Earth is made of mostly iron and nickel. The outer crust of the earth consists of a number of elements. The most abundant are oxygen (46%), silicon (27.7%), aluminum (8.1%), iron (5%), and calcium (3.6%).

Earth has one moon or natural satellite. You've probably seen it! The Earth's moon is the fifth largest moon in the solar system.

**Fun facts**

* You may think that the earth is a perfect circle, but it is actually an oblate spheroid. This is because the middle of the Earth or the equator bulges out slightly due to the spin of the Earth.
* The inner core of the Earth is hotter than the surface of the Sun.
* It is the fifth largest of the eight planets.
* Small earthquakes are happening somewhere on the Earth all the time.
* The Earth orbits the Sun at a speed of 67,000 miles per hour.

### Astronomical units of measurement

The astronomical system of units is a system of measurement developed for use in astronomy. It was adopted by the International Astronomical Union (IAU) in 1976 via Resolution No. 1,[1] and has been significantly updated in 1994 and 2009 (see astronomical constant).

The system was developed because of the difficulties in measuring and expressing astronomical data in International System of Units (SI units). In particular, there is a huge quantity of very precise data relating to the positions of objects within the Solar System which cannot conveniently be expressed or processed in SI units. Through a number of modifications, the astronomical system of units now explicitly recognizes the consequences of general relativity, which is a necessary addition to the International System of Units in order to accurately treat astronomical data.

The astronomical system of units is a tri-dimensional system, in that it defines units of length, mass and time. The associated astronomical constants also fix the different frames of reference that are needed to report observations.[2] The system is a conventional system, in that neither the unit of length nor the unit of mass are true physical constants, and there are at least three different measures of time.

#### Time

The astronomical unit of **time** is the day, defined as 86400 seconds. 365.25 days make up one Julian year.[1] The symbol D is used in astronomy to refer to this unit.

#### Mass

The astronomical unit of **mass** is the solar mass.[1] The symbol M☉ is often used to refer to this unit. The solar mass (M☉), 1.98892×1030 kg, is a standard way to express mass in astronomy, used to describe the masses of other stars and galaxies. It is equal to the mass of the Sun, about 333000 times the mass of the Earth or 1 048 times the mass of Jupiter.

Others: Jupiter Mass and Earth Mass.

Jupiter mass (MJ or MJUP) is the unit of mass equal to the total mass of the planet Jupiter. Jupiter mass is used to describe masses of the gas giants, such as the outer planets and extrasolar planets. It is also used in describing brown dwarfs and Neptune-mass planets.

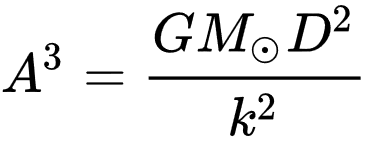
Earth mass (M⊕) is the unit of mass equal to that of the Earth. Earth mass is often used to describe masses of rocky terrestrial planets. It is also used to describe Neptune-mass planets.

#### Length

##### AU

The astronomical unit (symbol: au,[1][2][3] or au or AU) is a unit of **length**, roughly the distance from Earth to the Sun and equal to about 150 million kilometres (93 million miles) or ~8 light minutes. The actual distance varies by about 3% as Earth orbits the Sun, from a maximum (aphelion) to a minimum (perihelion) and back again once each year. The astronomical unit was originally conceived as the average of Earth's aphelion and perihelion; however, since 2012 it has been defined as exactly 149597870700 m

The unit distance A (the value of the astronomical unit in metres) can be expressed in terms of other astronomical constants:



where G is the Newtonian gravitational constant, M☉ is the solar mass, k is the numerical value of Gaussian gravitational constant and D is the time period of one day.

The astronomical unit is used primarily for measuring distances within the Solar System or around other stars. It is also a fundamental component in the definition of another unit of astronomical length, the parsec.

##### Parsec

The parsec (symbol: pc) is a unit of length used to measure the large distances to astronomical objects outside the Solar System, approximately equal to 3.26 light-years or 206,000 astronomical units (au), i.e., 30.9 trillion kilometres.

The nearest star, Proxima Centauri, is about 1.3 parsecs (4.2 light-years) from the Sun.[3] Most of the stars visible to the unaided eye in the night sky are within 500 parsecs of the Sun.

##### Light year

For most space objects, we use light-years to describe their distance. A light-year is the distance light travels in one Earth year. One light-year is about 6 trillion miles (9 trillion km). That is a 6 with 12 zeros behind it!

As defined by the International Astronomical Union (IAU), a light-year is the distance that light travels in vacuum in one Julian year (365.25 days).[2] Because it includes the word "year", the term light-year is sometimes misinterpreted as a unit of time.

The light-year is most often used when expressing distances to stars and other distances on a galactic scale, especially in non-specialist contexts and popular science publications.

Unit system: astronomy units

Unit of length

Symbol: ly^2

When we use powerful telescopes to look at distant objects in space, we are actually looking back in time. How can this be? Light travels at a speed of 186,000 miles (or 300,000 km) per second. This seems really fast, but objects in space are so far away that it takes a lot of time for their light to reach us. The farther an object is, the farther in the past we see it.

Our Sun is the closest star to us. It is about 93 million miles away. So, the Sun's light takes about 8.3 minutes to reach us. This means that we always see the Sun as it was about 8.3 minutes ago.

The next closest star to us (Proxima Centauri) is about 4.3 light-years away. So, when we see this star today, we’re actually seeing it as it was 4.3 years ago. All of the other stars we can see with our eyes are farther, some even thousands of light-years away.

In 2016, NASA's Hubble Space Telescope looked at the farthest galaxy ever seen, called GN-z11. It is 13.4 billion light-years away, so today we can see it as it was 13.4 billion years ago. That is only 400 million years after the big bang. It is one of the first galaxies ever formed in the universe.

Learning about the very first galaxies that formed after the big bang, like this one, helps us understand what the early universe was like.

## Questions

* What is the universe? How big is it and what is Hubble volume? Is universe expanding? What is the universe made of? What are dark matter and dark energy? How old is universe and what is BBT? Also name and explain some other theories regarding origin of universe. Scientists use which phenomena to see the echo of expansion of the universe? What are some interesting facts regarding universe?
* What is a star? Explain its lifecycle. Discuss its diff types and mention some fun facts.
* How idea of the galaxy became real? What is a galaxy? What is the name of our galaxy? Explain types of galaxies. Mention some fun facts about galaxies.
* What is a black hole? Can we see them? How are they formed? What is event horizon? Fun facts?
* What is an asteroid? Types? What is asteroid belt? Name largest asteroids and briefly describe trojan asteroids. Could an asteroid hit earth?
* What is a comet? Explain the process of coma and tail. What are short and long period comets? Describe the Kuiper belt and the Oort cloud. What are meteoroids, meteors and meteorites?
* What is a constellation? How many are there? Define star maps. Name most famous constellation. Why they are useful?
* Explain solar system. Why is it named so? Which planets and other objects are part of it?
* What is the Sun like? Which gases are abundant in sun? What is nuclear fusion? What is the relation of sun to energy?
* What is earth? Why it is unique among the Solar System’s planets? Briefly explain geography and composition of the Earth.
* What do you understand by astronomical units of measurement? What are different units used for length, mass and time?

## Process of Nature

### Solar and Lunar Eclipses

An eclipse occurs when one object in space blocks an observer from seeing another object in space. From Earth there are two main types of eclipses: solar eclipses and lunar eclipses.

**Solar Eclipse**: A solar eclipse occurs when the Moon passes in front of the Sun causing a shadow to fall on certain portions of the Earth. The eclipse is not seen from every place on Earth, but only from the locations where the shadow falls. From these locations, it appears as if the Sun has gone dark.

There are three main parts of the Moon's shadow during an eclipse called the umbra, penumbra, and antumbra. **Umbra** - The umbra is the portion of the Moon's shadow where the Moon completely covers the sun. **Antumbra** - The area of the shadow beyond the point of the umbra. Here the Moon is completely in front of the Sun, but doesn't cover the entire Sun. The outline of the Sun can be seen around the shadow of the Moon. **Penumbra** - The area of the shadow where only a portion of the Moon is in front of the Sun.

Depending on what part of the shadow you are located in, there are three types of eclipses: **Total** - A total eclipse is where the Sun is covered completely by the Moon. The portion of the Earth that is in the umbra experiences a total eclipse. **Annular** - An annular eclipse is when the Moon covers the Sun, but the Sun can be seen around the edges of the Moon. An annular eclipse occurs when the viewer is within the antumbra. **Partial** - A partial eclipse is when only a portion of the Sun is blocked by the Moon. It occurs when the observer is within the penumbra.

We should warn you here to never look directly at a solar eclipse. Even though it appears darker, the harmful rays of the Sun can still damage your eyes.

**Lunar Eclipse**: A lunar eclipse occurs when the Moon passes through the Earth's shadow. Lunar eclipses have the same three phases or types as solar eclipses including the umbra (total), antumbra (annular), and penumbra (partial).

Lunar eclipses can be seen by a much larger area of the Earth than solar eclipses. They also can be viewed without special equipment to protect the eyes. Lunar eclipses are not totally dark. The Moon will reflect some sunlight that is refracted by the Earth's atmosphere. The light that is refracted is reddish in color and can cause the Moon to appear a dark brownish-red.

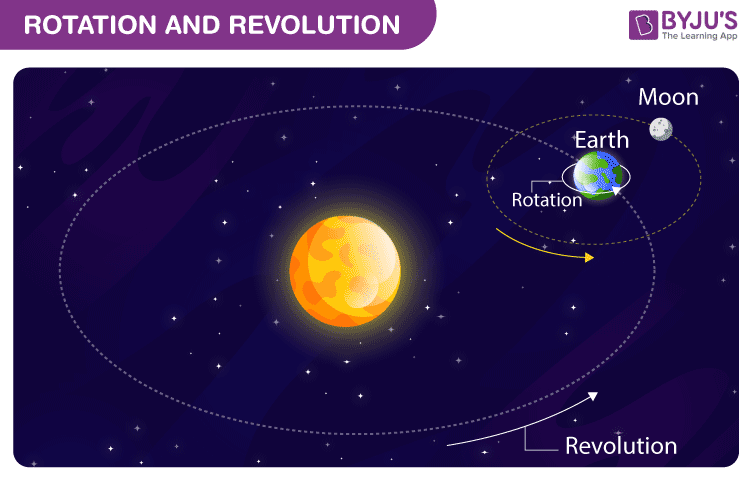
A total lunar eclipse occurs when Earth's umbra,the central, dark part of its shadow,covers all of the Moon's surface. When only part of the Moon's surface is obscured by Earth’s umbra, we see a partial lunar eclipse. A penumbral lunar eclipse happens when the Moon travels through the faint penumbral portion of Earth’s shadow.

Eclipses have been tracked and recorded by astronomers since ancient times by such civilizations as the Ancient Babylonians and the Ancient Chinese. Eclipses were often thought to be signs from the gods.

**Interesting Facts about Eclipses**

* The word "eclipse" comes from the Greek word "ekleipsis" which means "abandonment" or "downfall."
* The longest that a solar eclipse will last is seven and a half minutes.
* The most solar eclipses of any type that can occur on Earth within a year is five.
* A total solar eclipse occurs about every 1.5 years.
* Animals sometimes become confused and behave strangely during a total eclipse of the Sun.

### Rotation and Revolution



A rotation is a circular movement of an object around a centre of rotation. If three-dimensional objects like earth, moon and other planets always rotate around an imaginary line, it is called a rotation axis. If the axis passes through the body’s centre of mass, the body is said to rotate upon itself or spin.

Revolution is often used as a synonym for rotation. However, in many fields like astronomy and its related subjects, revolution is referred to as an orbital revolution. It is used when one body moves around another, while rotation is used to mean the movement around the axis. For example, the Moon revolves around the Earth and the Earth revolves around the Sun.

#### Rotation of the Earth

The spinning of the Earth around its axis is called ‘rotation’. The axis has an angle of 2312∘ and is perpendicular to the plane of Earth’s orbit. This means, Earth is tilted on its axis, and because of this tilt, the northern and southern hemispheres lean in a direction away from the Sun. The rotation of the Earth divides it into a lit-up half and a dark half, which gives rise to day and night. The direction of the earth rotation depends on the direction of viewing. When viewed looking down from the North Pole, Earth spins counterclockwise. On the contrary, when viewed looking down from the south pole, the earth spins in the clockwise direction.

Some of the benefits of the rotation of Earth are listed below:

* The earth rotation creates the diurnal cycle of lightness and darkness, temperature and humidity changes.
* The earth rotation causes the tides in the oceans and seas.

##### Effects of earthquake

Using the data from the Indonesian Earthquake, NASA calculated that earthquake affected Earth’s rotation, decreased the length of the day, shifted the North Pole by centimetres and slightly changed the planet’s shape. The earthquake that creates huge tsunami also changed the Earth’s rotation.

#### Revolution of the Earth

The movement of the Earth around the Sun in a fixed path is called a revolution. The Earth revolves from west to east i.e., in the anticlockwise direction. The Earth completes one revolution around the Sun in one year or precisely in 365.242 days. The revolution speed of the earth is 30 km/s-1.

### Weather variables

If you’re feeling hot or cold or feeling the rain fall on you, then you’re experiencing the effects of weather. Weather is about what’s going on in the sky and clouds right now. In other words, it’s the daily state of the atmosphere.

While climate refers to the average conditions of a place over a long period of time, weather is a specific, temporary event. It could last for ten minutes like a quick rain shower, or it might last for a few days like a storm or cloudy sky. Weather happens all the time, every day, and there's not much we can do about it.

There are six parts of weather: temperature, cloudiness, atmospheric pressure, precipitation, wind, and humidity.

we will be looking at and describing how to measure the different elements that make the weather. These elements, such as air temperature and precipitation, are normally called the weather variables because each element changes with time yet are all related.

#### Temperature

Temperature is the measure of hotness or coldness expressed in terms of any of several scales, including Fahrenheit and Celsius. Temperature indicates the direction in which heat energy will spontaneously flow—i.e., from a hotter body (one at a higher temperature) to a colder body (one at a lower temperature).

Three temperature scales are in general use today. The Fahrenheit (°F) temperature scale is used in the United States and a few other English-speaking countries. The Celsius (°C) temperature scale is standard in virtually all countries that have adopted the metric system of measurement, and it is widely used in the sciences. The Kelvin (K) scale, an absolute temperature scale (obtained by shifting the Celsius scale by −273.15° so that absolute zero coincides with 0 K), is recognized as the international standard for scientific temperature measurement.

During the night there is no direct sunlight, so there is more solar energy being lost than absorbed, causing air temperature during the night to be relatively cooler than during the day.

#### Humidity

Humidity is a measure of the amount of water vapor in the air. Humidity plays an important role in our daily weather. Without water vapor in the air, our weather might be like the weather on Mars. Could you imagine life without clouds, rain, snow, thunder, or lightning?

When you hear weather forecasters talk about humidity, you may hear them talk about two different terms: absolute humidity and relative humidity. Absolute humidity is the amount of water vapor divided by the amount of dry air in a certain volume of air at a particular temperature. The hotter the air is, the more water vapor it can hold.

Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity, which will depend upon the current air temperature. Relative humidity is the term weather forecasters use most often.

A relative humidity of 100% means that the air can't hold any more water vapor. It's totally saturated. When this occurs, it can rain. In fact, the relative humidity must be 100% where clouds are forming for it to rain. However, at ground level where the rain lands, the relative humidity can be less than 100%.

Humans are sensitive to changes in humidity, because our skin uses the air around us to get rid of moisture in the form of sweat. If the relative humidity is very high, the air is already saturated with water vapor and our sweat won't evaporate. When this happens, we feel hotter than the actual temperature.

Likewise, very low humidity can make us feel cooler than the actual temperature. This happens because the dry air helps sweat evaporate more quickly than usual. If the temperature outside is 75° F (23.8° C), humidity can make it feel warmer or cooler. A relative humidity of 0% would make it feel like it's only 69° F (20.5° C). On the other hand, a relative humidity of 100% would make it feel like it's 80° F (26.6° C).

#### Pressure

The air around you has weight, and it presses against everything it touches. That pressure is called atmospheric pressure, or air pressure. It is the force exerted on a surface by the air above it as gravity pulls it to Earth.

High pressure means the air is heavy, and it sinks. Sinking air makes the environment very stable. Under high pressure you can generally expect sunny skies and calm weather.

Low pressure is what causes active weather. The air is lighter than the surrounding air masses, so it rises, causing an unstable environment. Rising air makes the water vapor in the air condense and form clouds and rain for example. Low pressure systems lead to active weather like wind and rain, and also severe weather. Typically, air pressure will be between 1000 and 1030 millibars.

Atmospheric pressure is commonly measured with a barometer. In a barometer, a column of mercury in a glass tube rises or falls as the weight of the atmosphere changes. Meteorologists describe the atmospheric pressure by how high the mercury rises.

An atmosphere (atm) is a unit of measurement equal to the average air pressure at sea level at a temperature of 15 degrees Celsius (59 degrees Fahrenheit). One atmosphere is 1,013 millibars, or 760 millimeters (29.92 inches) of mercury.

**Atmospheric pressure drops as altitude increases**. The atmospheric pressure on Denali, Alaska, is about half that of Honolulu, Hawai'i. Honolulu is a city at sea level. Denali, also known as Mount McKinley, is the highest peak in North America.

As the pressure decreases, the amount of oxygen available to breathe also decreases. At very high altitudes, atmospheric pressure and available oxygen get so low that people can become sick and even die.

#### Precipitation

Precipitation is any type of water that forms in the Earth's atmosphere and then drops onto the surface of the Earth. Water vapor, droplets of water suspended in the air, builds up in the Earth's atmosphere. Water vapor in the atmosphere is visible as clouds and fog. Water vapor collects with other materials, such as dust, in clouds.

Precipitation condenses, or forms, around these tiny pieces of material, called cloud condensation nuclei (CCN). Clouds eventually get too full of water vapor, and the precipitation turns into a liquid (rain) or a solid (snow).

Precipitation is part of the water cycle. Precipitation falls to the ground as snow and rain. It eventually evaporates and rises back into the atmosphere as a gas. In clouds, it turns back into liquid or solid water, and it falls to Earth again. People rely on precipitation for fresh water to drink, bathe, and irrigate crops for food. The most common types of precipitation are rain, hail, and snow.

#### Circulation

Even with disruptions like weather fronts and storms, there is a consistent pattern to how air moves around our planet’s atmosphere. This pattern, called **atmospheric circulation**, is caused because the Sun heats the Earth more at the equator than at the poles. It's also affected by the spin of the Earth.

In the tropics, near the equator, warm air rises. When it gets about 10-15 km (6-9 miles) above the Earth surface it starts to flow away from the equator and towards the poles. Air that rose just north of the equator flows north. Air that rose just south of the equator flows south. When the air cools, it drops back to the ground, flows back towards the Equator, and warm again. The, now, warmed air rises again, and the pattern repeats. This pattern, known as **convection**, happens on a global scale. It also happens on a small scale within individual storms.

But because Earth is spinning, the air that moves north and south from the equator also turns with the spin of the Earth. Air going north turns to the right. Air traveling south turns to the left. The power of Earth’s spin to turn flowing air is known as the Coriolis Effect. If the Earth didn’t spin, there would be just one large convection cell between the equator and the North Pole and one large convection cell between the equator and the South Pole. But because the Earth does spin, convection is divided into three cells north of the equator and three south of the equator.

### Weather variations

The current condition and the state of the atmosphere at given time is called Weather. The axes of the earth are imaginary lines on which the earth rotates. It links up the two poles, South & North Pole. Both the axes and the two poles are tilted at the degree of 23.50 during a revolution. The tilting of the axes result in direct sun light falling on different places during different seasons. This causes variations in the durations of days, nights and seasons.

Relationship between the location of the overhead sun and the seasons: similarly the revolution of the earth and the titling of the axes result in different angle of the sun during different periods. When the sun is directly overhead, we call this overhead Sun. At this time the earth’s surface and midday sun forms a 900angel. Different locations of the overhead sun results in variations in the amount of solar radiation received in different areas under different periods.

#### Spring Equinox – 21 or 22 March

The overhead sun is over the equator, the equator receives the largest amount of solar radiation. At this time the northern hemisphere in is Spring Equinox, whereas the southern hemisphere is in the autumn equinox. The angle of the sun decreases towards the poles. On this day the two hemispheres receive a similar amount of solar radiation, and the length of the day and the night is the same at all places on the earth. After this it is spring in the northern hemisphere where the day is longer than the night. In the southern hemisphere it becomes autumn when the day is shorter than the night.

#### Summer Solstice – 21 or 22 June

The overhead sun is over the Tropic of Cancer, it receives the largest amount of solar radiation. At this time the northern hemisphere is in the summer solstice, whereas the southern hemisphere is in the winter solstice. Then the angle of the sun decreases towards the poles. On this day the length of the day time on the northern hemisphere is the longest in the year, whereas in the southern hemisphere it is the shortest of the year. Besides, there are 24 hours of daylight on the Arctic Circle and 24 hours of darkness/night on the Antarctic Circle.

#### Autumn Equinox – 22 or 23 September

Again the overhead sun is over the equator, the equator receives the largest amount of solar radiation. On this day the northern hemisphere is in autumn equinox, whereas the southern hemisphere is in spring equinox. The angle of the sun decreases towards the poles. On this day the two hemispheres receive a similar amount of solar radiation, and the length of the day and the night is the same at all places on the earth. After this it is autumn in the northern hemisphere where the day is shorter than the night. In the southern hemisphere it becomes spring when the day is longer than the night.

#### Winter Solstice – 21 or 22 December

The overhead sun is over the Tropic of Capricorn, it receives the largest amount of solar radiation. On this time the northern hemisphere is in the winter solstice, whereas the southern hemisphere is in the summer solstice. Then the angle of the sun decreases towards the poles. On this day the length of the daytime on the northern hemisphere is the shortest in the year, whereas in the southern hemisphere it is the longest of the year. Besides, there are 24 hours of daylight on the Antarctic Circle and 24 hours of darkness/night on the Arctic Circle.

## Questions

* What is a solar eclipse? What is umbra, antumbra and penumbra? Explain types of solar eclipses. Why should we not look at a solar eclipse?
* Differentiate btw rotation and revolution. Do earthquakes affect the Earth’s rotation?
* What are weather variables? Define temp. What are different scales used to measure temp? Why is air temp lower at night?
* What is humidity? Differentiate between relative and absolute. How can humidity make us feel cooler or hotter than the actual temp?
* What is an atmospheric pressure? What are the effects of low and high atm pressure? When pressure decreases?
* Explain precipitation and circulation.
* Define weather variations and discuss 4 prominent variations.

## Natural Hazards and Disasters

### Earthquake

Earthquakes happen when two large pieces of the Earth's crust suddenly slip. This causes shock waves to shake the surface of the Earth in the form of an earthquake.

Earthquakes usually occur on the edges of large sections of the Earth's crust called tectonic plates. These plates slowly move over a long period of time. Sometimes the edges, which are called fault lines, can get stuck, but the plates keep moving. Pressure slowly starts to build up where the edges are stuck and, once the pressure gets strong enough, the plates will suddenly move causing an earthquake.

Generally, before and after a large earthquake there will be smaller earthquakes. The ones that happen before are called foreshocks. The ones that happen after are called aftershocks. Scientists don't really know if an earthquake is a foreshock until the bigger earthquake occurs.

Shock waves from an earthquake that travel through the ground are called seismic waves. They are most powerful at the center of the earthquake, but they travel through much of the earth and back to the surface. They move quickly at 20 times the speed of sound.

Scientists use seismic waves to measure how big an earthquake is. They use a device called a seismograph to measure the size of the waves. The size of the waves is called the magnitude. To tell the strength of an earthquake scientists use a scale called the Moment Magnitude Scale or MMS (it used to be called the Richter scale). The larger the number on the MMS scale, the larger the earthquake. You usually won't even notice an earthquake unless it measures at least a 3 on the MMS scale. Here are some examples of what may happen depending on the scale:

* 4.0 - Could shake your house as if a large truck were passing close by. Some people may not notice.
* 9.0 and up - Whole cities flattened and large-scale damage.

The place where the earthquake starts, below the surface of the earth, is called the hypocentre. The place directly above this on the surface is called the epicentre. The earthquake will be the strongest at this point on the surface.

Unfortunately, scientists cannot predict earthquakes. The best they can do today is point out where fault lines are, so we know where earthquakes are likely to occur.

**Fun facts**

* The largest earthquake ever recorded in the world was in Chile in 1960. It measured a 9.6 on the Richter Scale.
* They can cause huge waves in the ocean called tsunamis.
* Movement of tectonic plates has formed large mountain ranges like the Himalayas and the Andes.
* Earthquake in oceans is known as Tsunami, which is equally devastating.

#### Causes

Earthquakes can be human-made or natural, although the latter is more abundant. These earthquakes are not random; rather, they are the effect of different changes occurring in the earth’s crust for a long time. The main causes of earthquakes fall into five categories:

**1. Volcanic Eruptions**

The main cause of the earthquake is volcanic eruptions. Such type of earthquakes occurs in areas, with frequent volcanic activities. When boiling lava tries to break through the surface of the earth, with the increased pressure of gases, certain movements caused in the earth’s crust. Movement of lava beneath the surface of the earth can also cause certain disruptions. This sends shockwaves through the earth, causing damage. These earthquakes are mild. Their range is also limited. However, there have been certain exceptions, with volcanic earthquakes bring havoc and death to thousands of people.

**2. Tectonic Movements**

The surface of the earth consists of some plates, comprising of the upper mantle. These plates are always moving, thus affecting the earth’s crust. These movements categorized into three types: constructive, destructive, and conservative. Constructive is when two plates move away from each other, they correspond to mild earthquakes. When two plates move towards each other and collide, this is known as destructive plate boundaries. This is very destructive. Conservative corresponds to passing by of plates of crust. Earthquakes of this type have varying intensities.

**3. Geological Faults**

A geological fault is known as the displacement of plates of their original plane. The plane can be horizontal or vertical. These planes are not formed suddenly but slowly develop over a long period. The movement of rocks along these planes brings about tectonic earthquakes. These faults occur due to the impact of geological forces. The displacement of plates creates the fracturing of rocks, which releases a lot of energy. This type of earthquake can be disastrous.

**4. Man-Made**

The interference of man with nature can also become a cause of the earthquake. The disturbance of crustal balance due to heavy clubbing of water in dams can cause earthquakes. Nuclear bombing can send specific types of shockwaves throughout the surface of the earth, which can disturb the natural alignment of tectonic plates. Mining can also cause disturbance due to the extensive removal of rocks from different areas.

**5. Minor Causes**

Some minor causes such as landslides, avalanches, the collapse of heavy rocks, etc. can also cause minor shockwaves. The gases beneath the surface of earth contract and expand, giving rise to movements in plates beneath the crust. The plutonic earthquake occurs because of adjustments in rock beds in the interior of the earth’s crust. All these factors correspond to minor earthquakes, but sometimes these can also vary to moderate earthquakes.

### Volcanic eruption

Deep within the Earth it is so hot that some rocks slowly melt and become a thick flowing substance called magma. Since it is lighter than the solid rock around it, magma rises and collects in magma chambers. Eventually, some of the magma pushes through vents and fissures to the Earth's surface. Magma that has erupted is called lava.

Some volcanic eruptions are explosive, and others are not. The explosivity of an eruption depends on the composition of the magma. If magma is thin and runny, gases can escape easily from it. When this type of magma erupts, it flows out of the volcano. A good example is the eruptions at Hawaii’s volcanoes. Lava flows rarely kill people because they move slowly enough for people to get out of their way. If magma is thick and sticky, gases cannot escape easily. Pressure builds up until the gases escape violently and explode. A good example is the eruption of Washington’s Mount St. Helens. In this type of eruption, the magma blasts into the air and breaks apart into pieces called **tephra**. Tephra can range in size from tiny particles of ash to house-size boulders.

Explosive volcanic eruptions can be dangerous and deadly. They can blast out clouds of hot tephra from the side or top of a volcano. These fiery clouds race down mountainsides destroying almost everything in their path. Ash erupted into the sky falls back to Earth like powdery snow. If thick enough, blankets of ash can suffocate plants, animals, and humans. When hot volcanic materials mix with water from streams or melted snow and ice, mudflows form. Mudflows have buried entire communities located near erupting volcanoes.

**Fun facts**

* The tallest volcano we know of in the Solar System is on Mars. It is called Olympus Mons and is 17 miles tall.
* The largest volcano on earth is Mauna Loa on the Hawaii Big Island. The tallest is Mauna Kea which is right next to it.

### Tsunami

Tsunamis are large and powerful ocean waves that grow in size as they reach the shore. They can cause major damage as they rush inland flooding cities and destroying homes.

Tsunamis are caused by a large displacement of water. Think of when you are sitting in the bathtub and you move forward in the tub. This can cause a relatively large wave. The same thing happens in the ocean when a large amount of water is suddenly moved. A number of events may cause this kind of movement including earthquakes, landslides, volcanic eruptions, glaciers breaking off, and even meteorites. Most tsunamis are caused by **earthquakes**. An earthquake occurs when a large area of the Earth's crust suddenly moves. When this happens underwater, big gaps may appear on the ocean floor. When water moves in to fill this gap, a tsunami is born.

Tsunamis can occur in any major body of water. They are most common in the Pacific Ocean where there are lots of underwater earthquakes and volcanoes. Countries with long coastlines on the Pacific Ocean such as Japan, Chile, and the United States are all at risk of being hit by a tsunami. However, tsunamis can happen anywhere. In 2004 a massive earthquake in the Indian Ocean caused a devastating tsunami that killed over 230,000 people.

Even though tsunamis slow down as they approach the shoreline, they can still be travelling at highway speeds of over 50 miles per hour. A huge wall of water traveling at this speed can cause major damage. A large tsunami can travel many miles inland and wiping out entire coastal cities.

**Fun facts**

* Although tsunamis are sometimes called tidal waves they have nothing to do with the ocean's tides.
* The series of waves generated by a tsunami is called a wave train.
* The first wave of a tsunami may not be the biggest. There may be bigger and stronger waves to come.
* The word "tsunami" means "harbor wave" in Japanese.
* The warning system in the Pacific Ocean is called the DART system which stands for Deep-ocean Assessment and Reporting of Tsunamis.

### Avalanche

Avalanches are masses of snow, ice, and rocks that fall rapidly down a mountainside. They can be deadly. Falling masses of snow and ice, avalanches pose a threat to anyone on snowy mountainsides. Beautiful to witness from afar, they can be deadly because of their intensity and seeming unpredictability.

#### Types

To help in understanding of avalanches, they have been classified into four types.

**Loose Snow Avalanche**

They are common on steep slopes and are seen after a fresh snowfall. Since the snow does not have time to settle down fully or has been made loose by sunlight, the snow-pack is not very solid. Such avalanches have a single point of origin, from where they widen as they travel down the slope.

Loose Snow Avalanches in turn could cause a **Slab Avalanche**, which are characterized by a the fall of a large block of ice down the slopes. Thin slabs cause fairly small amounts of damage, while the thick ones are responsible for MANY FATALITIES.

**Powder Snow Avalanche** A mix of the other forms, Loose Snow and Slab. The bottom half of this avalanche consists of a slab or a dense concentration of snow, ice and air. Above this is a cloud of powdered snow, which can snowball into a larger avalanche as it progresses down the slope. The speed attained by this avalanche can cross 190 miles per hour and they can cross large distances.

**Wet Snow Avalanche** These are quite dangerous as they travel slowly due to friction, which collects debris from the path fairly easily. The avalanche comprises of water and snow at the beginning, but understanding of avalanches has showed us that it can pick up speed with ease.

#### Features

Avalanches contain three main features: the starting zone, the avalanche track, and the runout zone. Avalanches launch from the starting zone. That’s often the most unstable part of the stope, and generally higher on the mountain.

Once the avalanche starts to slide, it continues down the avalanche track, the natural path it follows downhill. After avalanches, large clearings or missing chutes of trees provide clues to an avalanche’s trajectory.

The avalanche finally comes to a stop at the bottom of a slope, in the runout zone, where the snow and debris pile up.

#### Causes

Avalanches are most common during the winter, December to April in the Northern Hemisphere, but they do occur year-round.

To get an avalanche, you need a surface bed of snow, a weaker layer that can collapse, and an overlaying snow slab. The highest risk period is during and immediately after a snow storm. Underlying snowpack, overloaded by a quick deluge of snow, can cause a weak layer beneath the slab to fracture naturally.

Human-triggered avalanches start when somebody walks or rides over a slab with an underlying weak layer. The weak layer collapses, causing the overlaying mass of snow to fracture and start to slide. Earthquakes can also trigger strong avalanches.

### Cyclone

Cyclones can be the **most intense storms** on Earth. A cyclone is a system of winds rotating counter-clockwise in the Northern Hemisphere around a low-pressure centre. The swirling air rises and cools, creating clouds and precipitation.

There are two types of cyclones: middle latitude (mid-latitude) cyclones and tropical cyclones. Mid-latitude cyclones are the main cause of winter storms in the middle latitudes. Tropical cyclones are also known as hurricanes.

An anticyclone is the opposite of a cyclone. An anticyclone’s winds rotate clockwise in the Northern Hemisphere around a center of high pressure. Air comes in from above and sinks to the ground. High pressure centers generally have fair weather.

### Mid-latitude cyclones

Mid-latitude cyclones, sometimes called wave cyclone/extratropical cyclones, form at the **polar front** (the transition region separating warmer tropical air from colder polar air in the mid-latitudes) when the temperature difference between two air masses is large. These air masses blow past each other in opposite directions. **Coriolis Effect** deflects winds to the right in the Northern Hemisphere, causing the winds to strike the polar front at an angle. Warm and cold fronts form next to each other. Most winter storms in the middle latitudes, including most of the United States and Europe, are caused by mid-latitude cyclones.The warm air at the cold front rises and creates a low pressure cell. Winds rush into the low pressure and create a rising column of air. The air twists, rotating counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Since the rising air is moist, rain or snow falls.

### Hurricane/Tropical Cyclone/Typhoon

Hurricanes and typhoons are the same weather phenomenon: tropical cyclones. A tropical cyclone is a generic term used by meteorologists to describe a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has closed, low-level circulation.

The weakest tropical cyclones are called tropical depressions. If a depression intensifies such that its maximum sustained winds reach 39 miles per hour, the tropical cyclone becomes a tropical storm. Once a tropical cyclone reaches maximum sustained winds of 74 miles per hour or higher, it is then classified as a hurricane, typhoon, or tropical cyclone, depending upon where the storm originates in the world. In the North Atlantic, central North Pacific, and eastern North Pacific, the term hurricane is used. The same type of disturbance in the Northwest Pacific is called a typhoon. Meanwhile, in the South Pacific and Indian Ocean, the generic term tropical cyclone is used, regardless of the strength of the wind associated with the weather system.

Hurricane form over the warm ocean water of the tropics. When warm moist air over the water rises, it is replaced by cooler air. The cooler air will then warm and start to rise. This cycle causes huge storm clouds to form. These storm clouds will begin to rotate with the spin of the Earth forming an organized system. If there is enough warm water, the cycle will continue and the storm clouds and wind speeds will grow causing a hurricane to form.

Tropical cyclones occur over the ocean in areas near the equator. This is because there is plenty of warm water in these areas to allow the storms to form.

When hurricanes strike land they can cause huge amounts of damage. Most of the damage is caused by flooding and storm surge. Storm surge is when the ocean level rises at the coastline due to the power of the storm. Hurricanes also cause damage with high speed winds that can blow down trees and damage homes. Many hurricanes can develop several small tornados as well.

Tropical cyclones are categorized according to the speed of sustained winds.

* Category 1 - 74 to 95 mph
* Category 2 - 96 to 110 mph
* Category 3 - 111 to 129 mph
* Category 4 - 130 to 156 mph
* Category 5 - 157 or higher mph

### Tornadoes/Twister

Tornadoes are one of the most violent and powerful types of weather. They consist of a very fast rotating column of air that usually forms a funnel shape. They can be very dangerous as their high speed winds can break apart buildings, knock down trees, and even toss cars into the air.

When we talk about tornadoes, we are usually talking about large tornadoes that occur during thunderstorms. These types of tornadoes form from very tall thunderstorm clouds called cumulonimbus clouds. However, it takes more than just a thunderstorm to cause a tornado. Other conditions must occur for a tornado to form. The typical steps for the formation of a tornado are as follows:

* A large thunderstorm occurs in a cumulonimbus cloud
* A change in wind direction and wind speed at high altitudes causes the air to swirl horizontally
* Rising air from the ground pushes up on the swirling air and tips it over
* The funnel of swirling air begins to suck up more warm air from the ground
* The funnel grows longer and stretches toward the ground
* When the funnel touches the ground it becomes a tornado

Tornadoes are categorized by their wind speed and the amount of damage they cause using a scale called the "Enhanced Fujita" scale. It is usually abbreviated as the "EF" scale.

Thunderstorms form when warm, moist air rises into cold air. The warm air becomes cooler, which causes moisture, called water vapor, to form small water droplets - a process called condensation. The cooled air drops lower in the atmosphere, warms and rises again.

**Category: Wind Speed: Strength**

From EF-0: 65-85 MPH: Weak to EF-5: over 200 MPH: Violent

#### Characteristics

**Shape** - Tornadoes typically look like a narrow funnel reaching from the clouds down to the ground. Sometimes giant tornadoes can look more like a wedge. **Size** - Tornadoes can vary widely in size. A typical tornado in the United States is around 500 feet across, but some may be as narrow as just a few feet across or nearly two miles wide. **Wind Speed** - The wind speed of a tornado can vary from 65 to 250 miles per hour. **Colour** - Tornadoes may appear different colors depending on the local environment. Some may be nearly invisible, while others may appear white, grey, black, blue, red, or even green. **Rotation** - When viewed from above, most tornadoes rotate counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere.

### Drought

A drought is a prolonged period with less-than-average amounts of rain or snow in a particular region. The severity of the drought depends on the amount of time that a region receives below-average precipitation.

For example, a few weeks without rain could stress a farmer’s crops during the growing season. This is called a flash drought. But it could take a much longer dry period to see a full drought that would affect a region’s water supply.

A drought is caused by drier than normal conditions that can eventually lead to water supply problems. Really hot temperatures can make a drought worse by causing moisture to evaporate from the soil. Just because a region is hot and dry doesn't necessarily mean it is going through a drought. Droughts only occur when an area is abnormally dry. Here's why:

Rain and snow don’t fall evenly across Earth. Some regions are routinely wet and others are routinely dry. From season to season — and from year to year — the amount of rain or snow in a location can vary.

However, over a period of many years, the average amount of precipitation in a region is fairly consistent. For example, in the deserts of the American Southwest, the average precipitation is less than 3 inches per year. But, the average yearly precipitation in Atlanta is about 50 inches.

When a particular area gets less rain than usual, the soil gets much less moisture, too. The soil starts drying out and plants die. When this pattern continues for several weeks, months or years, the flow of streams and rivers decreases and water levels in lakes, reservoirs and wells fall. Eventually, the unusual dry weather causes water supply issues, and the dry period becomes a drought.

The only way a drought can really end is with enough regular soaking rains or significant snow. Rains that soak into the soil can replenish the groundwater. Groundwater provides water to plants and can refill streams during non-rainy periods.

One soaking rain may help improve drought conditions. However, multiple soaking rains over several months are needed to truly return things to normal.

Atmospheric conditions such as climate change, ocean temperatures, changes in the jet stream, and changes in the local landscape are all factors that contribute to drought.

Jet streams form when warm air masses meet cold air masses in the atmosphere. The Sun doesn't heat the whole Earth evenly. That's why areas near the equator are hot and areas near the poles are cold.

### Wildfire

A wildfire is an uncontrolled fire that burns in the wildland vegetation, often in rural areas. Wildfires can burn in forests, grasslands, savannas, and other ecosystems, and have been doing so for hundreds of millions of years. They are not limited to a particular continent or environment.

Wildfires can start with a natural occurrence—such as a lightning strike—or a human-made spark. However, it is often the weather conditions that determine how much a wildfire grows. Wind, high temperatures, and little rainfall can all leave trees, shrubs, fallen leaves, and limbs dried out and primed to fuel a fire. **Topography plays a big part too**: flames burn uphill faster than they burn downhill.

Wildfires also help keep ecosystems healthy. They can kill insects and diseases that harm trees. By clearing scrub and underbrush, fires can make way for new grasses, herbs, and shrubs that provide food and habitat for animals and birds. At a low intensity, flames can clean up debris and underbrush on the forest floor, add nutrients to the soil, and open up space to let sunlight through to the ground. That sunlight can nourish smaller plants and give larger trees room to grow and flourish.

California’s Dixie fire – the second-largest in the state’s history, and Siberia’s wildfires are being touted as some of the largest fires in recorded history.

Rising global temperatures are increasingly threatening both humans and wildlife. Forest fires, which formerly occurred mostly in certain places like California in the US, are now occurring in Turkey, Greece and other countries of southern Europe with increasing frequency and intensity resulting in heatwaves and parched lands.

### Urban fire

Urban fire occurs primarily in cities or towns with the potential to rapidly spread to adjoining structures. These fires damage and destroy homes, schools, commercial buildings, and vehicles.

In residential structures, cooking, incendiary or suspicious origin, heating, and electrical distribution were the leading causes of fires. Cooking fires accounted for over one-quarter of all residential structure fires in urban areas.

### Disaster Risk Management

Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

Disaster risk management actions can be distinguished between prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management, also called residual risk management.

**Prospective** disaster risk management activities address and seek to avoid the development of new or increased disaster risks. They focus on addressing disaster risks that may develop in future if disaster risk reduction policies are not put in place. Examples are **better land-use planning** or disaster-resistant water supply systems.

**Corrective** disaster risk management activities address and seek to remove or reduce disaster risks which are already present and which need to be managed and reduced now. Examples are the retrofitting of critical infrastructure or the **relocation of exposed populations** or assets.

**Compensatory** disaster risk management activities strengthen the social and economic resilience of individuals and societies in the face of residual risk that cannot be effectively reduced. They include **preparedness, response and recovery activities, but also a mix of different financing instruments**, such as national contingency funds, contingent credit, insurance and reinsurance and social safety nets.

## Questions

* Define earthquake. Where do earthquakes happen? What are Foreshocks and Aftershocks? Explain seismic waves. Why do scientists use seismic waves? What is the purpose of Richter scale? Differentiate btw epicentres and hypocentres. Can scientists predict earthquake? What are the main causes?
* Explain volcanic eruption. Which eruption is explosive?
* What are tsunamis? What can cause a tsunami? Where do they occur? Why are they dangerous?
* Explain cyclone and describe mid-latitude cyclones.
* What is a hurricane? What are different names used for it and why? How do they form? Where do they occur? Why are they dangerous? How are they categorized?
* Define tornado. How do they form? Discuss its characteristics. How are they categorized?
* What is drought? How is it caused? How can it end?
* What is a wildfire? What causes it? Discuss the manifestations of climate change induced changes in the patterns of wildfire. What loss can be caused by it?
* What is urban fire and mention causes behind it? How can it be prevented?
* Discuss disaster risk management and its types.

## Energy resources

### Renewable

Renewable energy uses energy sources that are not "used up". For example, solar power from the sun is renewable as we won't "use up" all the sunlight from the sun. Examples of non-renewable energy sources include fossil fuels like coal and oil. Once we use or burn these resources, they are gone forever.

Much of the world relies on non-renewable energy to heat their homes, power their electronic devices, and power their cars. Once these energy sources are used up, they will be gone forever. Developing technologies that can efficiently use renewable energy sources is critical to our future.

Many renewable energy sources are also better for the environment than burning fossil fuels. They produce less pollution which will help protect the environment and provide us with cleaner air and water.

#### Wind energy

Wind power is energy, such as electricity, that is generated directly from the wind. It is considered a renewable energy source because there is always wind on the Earth and we aren't "using up" the wind when we make energy from it. Wind power also does not cause pollution.

In order to create a lot of energy capable of powering thousands of homes, energy companies build large wind farms with lots of wind turbines. They usually build these in consistently windy places. Some companies build wind farms out in the ocean. These are called offshore wind farms.

**A wind turbine works the opposite of a fan**. Instead of using electricity to turn the blades to make wind, it uses the wind to turn the blades to make electricity. Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces (generates) electricity.

One major issue some people have with wind power is how the wind turbines mess up the view or landscape. Other drawbacks include the large blades killing birds and noise pollution from the turbine. Most people agree that the positives of a fully renewable and clean energy resource far outweigh the negatives.

#### Solar energy

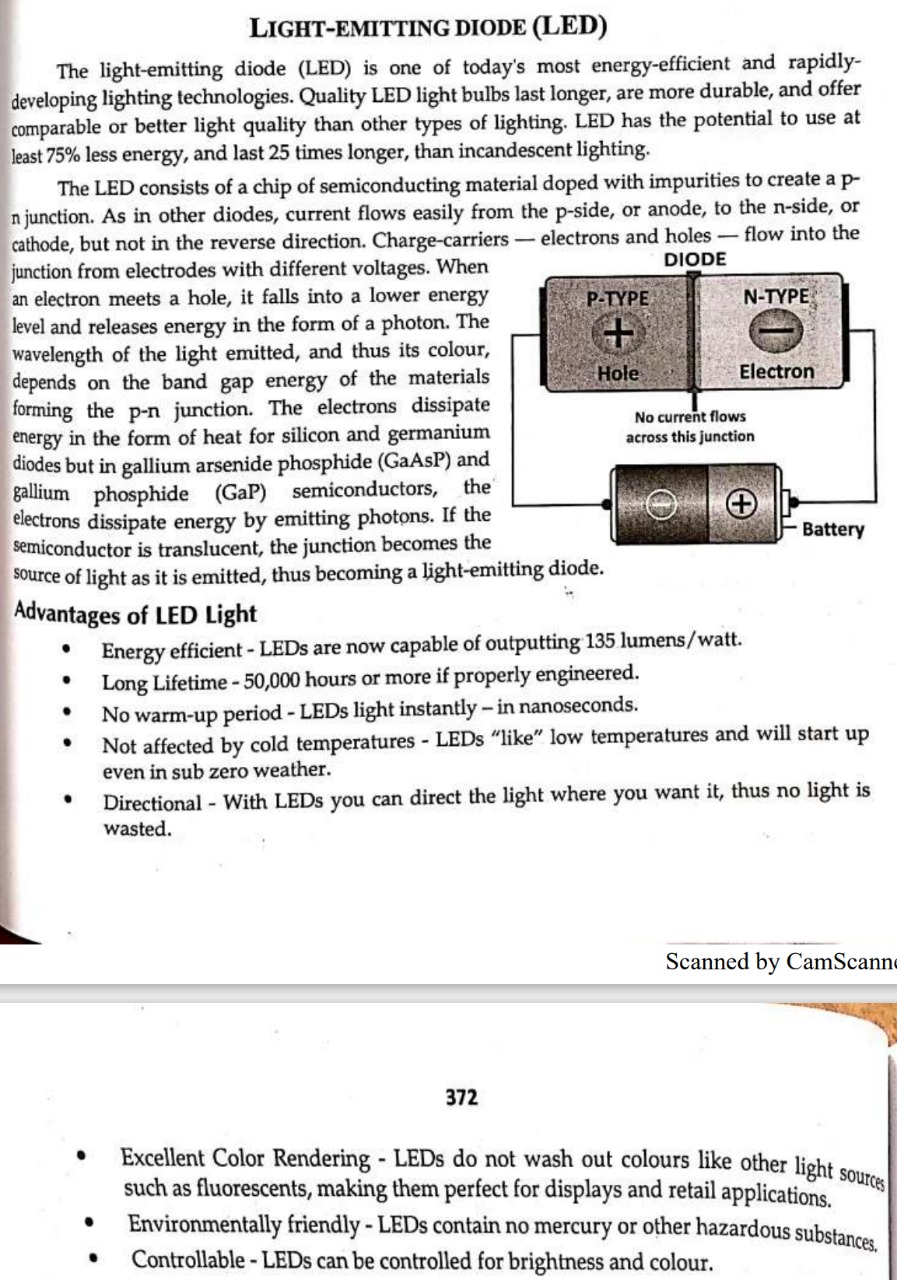
The primary source of all energy on planet Earth is from the sun. Solar power is power generated directly from sunlight. Solar power can be used for heat energyor converted into electric energy.

When most of us think of solar power, we think of the solar cells that turn rays of sunshine into electricity. Solar cells are also called photovoltaic cells. The word "photovoltaic" comes from the word **"photons", which are particles that make up sunlight**, as well as the word "volts", which is a measurement of electricity. Today solar cells are commonly used in small handheld devices like calculators and wrist watches. They are becoming more popular for buildings and homes as they become more efficient. One nice thing about solar cells is that they can be placed on the roof of a building or home, not taking up any extra space.

Solar cells convert the energy of photons from the sun into electricity. When the photon hits the top of the cell, electrons will be attracted to the surface of the cell. This causes a voltage to form between the top and the bottom layers of the cell. When an electric circuit is formed across the top and the bottom of the cell, current will flow, powering electrical equipment. It takes a lot of solar cells to power a building or a home. In this case, a number of solar cells are connected into a large array of cells that can produce more total energy.

Solar power has two major drawbacks. One drawback is that the amount of sunshine in a specific place changes due to the time of day, the weather, and the time of the year. The other drawback is that with current technology it takes a lot of expensive photovoltaic cells to produce a decent amount of electricity.

#### Led energy



#### Hydropower

**Hydropower** - Water from a dam or a river can be used to spin turbines and generate electricity. Falling or flowing water from a big river has a lot of energy. We can harness this by forcing the water through a pipe called a penstock. As the water flows through the pipe it turns the blades of a turbine which spins an electric generator. As long as the water is flowin g, the generator will be able to provide electricity.

Like any power source there are some drawbacks to hydropower. One drawback is the loss of land and the damage to the local ecosystem caused when a lake is created by a dam. This can also cause people to have to relocate and leave their homes. Another disadvantage is methane emissions generated by the reservoirs. Dams and turbines can also hurt fish and disrupt their migration to spawning grounds.

#### Others

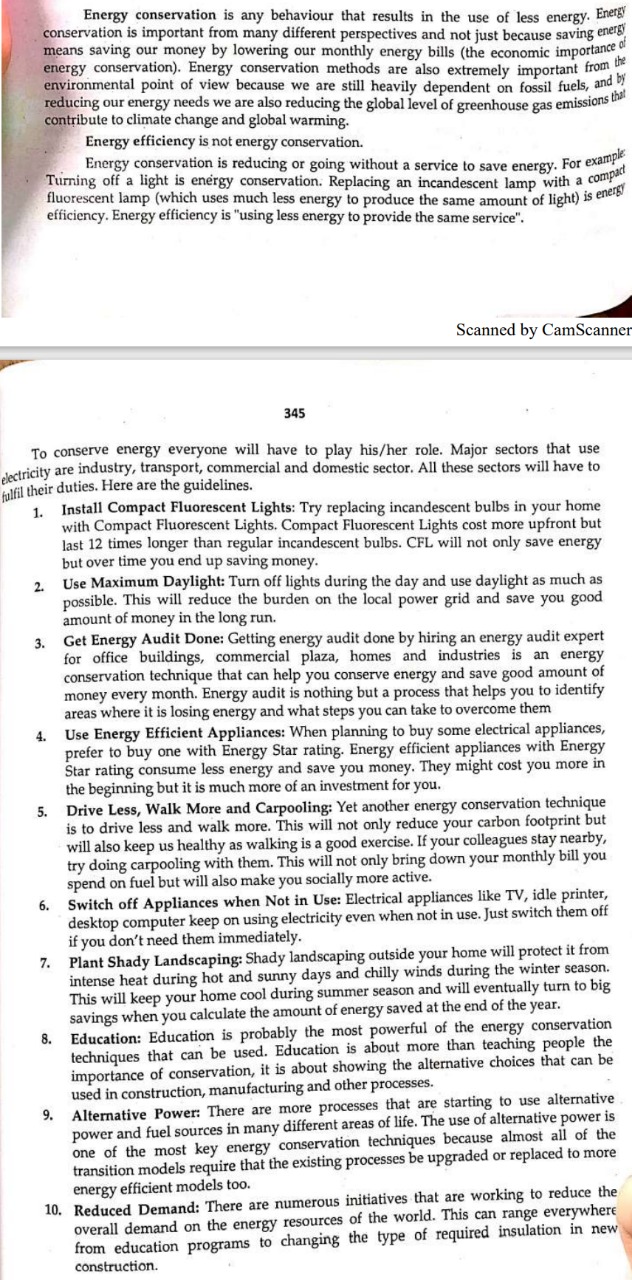
**Wave and Tidal Power** - This new technology is working on ways to harness the vast power of the ocean's waves and tides.

**Geothermal Energy** - Heat from inside the Earth can be used to heat homes and buildings with heat pumps. Steam from inside the Earth can also be used to generate electricity.

**Biomass Energy** - Plants gather energy from the sun by photosynthesis. We can harness this energy by burning plants such as trees as well as creating fuel from plants such as ethanol and biodiesel. Even gas from trash and manure can be used to create energy.

### Non-renewable energy sources

### Energy conservation and sustainability



## Atomic structure

### Atom

An atom is the smallest unit of matter that retains all of the chemical properties of an element. Atoms combine to form molecules, which then interact to form solids, gases, or liquids. For example, water is composed of hydrogen and oxygen atoms that have combined to form water molecules. Many biological processes are devoted to breaking down molecules into their component atoms so they can be reassembled into a more useful molecule.

### Atomic particles

Atoms consist of three basic particles: protons, electrons, and neutrons. The nucleus (center) of the atom contains the protons (positively charged) and the neutrons (no charge). The outermost regions of the atom are called electron shells and contain the electrons (negatively charged). Atoms have different properties based on the arrangement and number of their basic particles.

The hydrogen atom (H) contains only one proton, one electron, and no neutrons. This can be determined using the atomic number and the mass number of the element (see the concept on atomic numbers and mass numbers).

Diagram, schematic

Description automatically generated

**Structure of an atom**: Elements, such as helium, depicted here, are made up of atoms. Atoms are made up of protons and neutrons located within the nucleus, with electrons in orbitals surrounding the nucleus.

### Atomic mass

Protons and neutrons have approximately the same mass, about 1.67 × 10-24 grams. Scientists define this amount of mass as one atomic mass unit (amu) or one Dalton. Although similar in mass, protons are positively charged, while neutrons have no charge. Therefore, the number of neutrons in an atom contributes significantly to its mass, but not to its charge.

Electrons are much smaller in mass than protons, weighing only 9.11 × 10-28 grams, or about 1/1800 of an atomic mass unit. Therefore, they do not contribute much to an element’s overall atomic mass. When considering atomic mass, it is customary to ignore the mass of any electrons and calculate the atom’s mass based on the number of protons and neutrons alone.

Electrons contribute greatly to the atom’s charge, as each electron has a negative charge equal to the positive charge of a proton. Scientists define these charges as “+1” and “-1. ” In an uncharged, neutral atom, the number of electrons orbiting the nucleus is equal to the number of protons inside the nucleus. In these atoms, the positive and negative charges cancel each other out, leading to an atom with no net charge.

Table

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### Atomic number and mass number

The atomic number is the number of protons in an element, while the mass number is the number of protons plus the number of neutrons.

Neutral atoms of an element contain an equal number of protons and electrons. The number of protons determines an element’s atomic number (Z) and distinguishes one element from another. For example, carbon’s atomic number (Z) is 6 because it has 6 protons. The number of neutrons can vary to produce **isotopes**, which are atoms of the same element that have different numbers of neutrons. The number of electrons can also be different in atoms of the same element, thus producing ions (charged atoms). For instance, iron, Fe, can exist in its neutral state, or in the +2 and +3 ionic states.

An element’s mass number (A) is the sum of the number of protons and the number of neutrons. The small contribution of mass from electrons is disregarded in calculating the mass number. This approximation of mass can be used to easily calculate how many neutrons an element has by simply subtracting the number of protons from the mass number. Protons and neutrons both weigh about one atomic mass unit or amu. Isotopes of the same element will have the same atomic number but different mass numbers.

A picture containing text

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Scientists determine the atomic mass by calculating the mean of the mass numbers for its naturally-occurring isotopes. Often, the resulting number contains a decimal. For example, the atomic mass of chlorine (Cl) is 35.45 amu because chlorine is composed of several isotopes, some (the majority) with an atomic mass of 35 amu (17 protons and 18 neutrons) and some with an atomic mass of 37 amu (17 protons and 20 neutrons).

Given an atomic number (Z) and mass number (A), you can find the number of protons, neutrons, and electrons in a neutral atom. For example, a lithium atom (Z=3, A=7 amu) contains three protons (found from Z), three electrons (as the number of protons is equal to the number of electrons in an atom), and four neutrons (7 – 3 = 4).

### Isotopes

Isotopes are various forms of an element that have the same number of protons but a different number of neutrons. Some elements, such as carbon, potassium, and uranium, have multiple naturally-occurring isotopes. Isotopes are defined first by their element and then by the sum of the protons and neutrons present.

* Carbon-12 (or 12C) contains six protons, six neutrons, and six electrons; therefore, it has a mass number of 12 amu (six protons and six neutrons).
* Carbon-14 (or 14C) contains six protons, eight neutrons, and six electrons; its atomic mass is 14 amu (six protons and eight neutrons).

While the mass of individual isotopes is different, their physical and chemical properties remain mostly unchanged.

Isotopes do differ in their stability. Carbon-12 (12C) is the most abundant of the carbon isotopes, accounting for 98.89% of carbon on Earth. Carbon-14 (14C) is unstable and only occurs in trace amounts.

**Radioactive isotopes**: The isotopes which are unstable due to presence of extra neutrons in their nuclei and emit various types of radiations, are called radioactive isotopes or radioisotopes. For example: Carbon – 14

Hydrogen is the only element where the isotopes are given specific names. Common hydrogen, which has zero neutrons, is called **protium**. Hydrogen with one neutron is called **deuterium** and hydrogen with two neutrons is called **tritium**.

Diagram

Description automatically generated

All elements have a number of isotopes. Hydrogen has the fewest number of isotopes with only three. The elements with the most isotopes are **caesium and xenon** with 36 known isotopes.

**Interesting facts**

* Many elements only exist in an unstable or radioactive form.
* All non-natural or man-made elements are radioactive isotopes.
* Heavier isotopes tend to react more slowly than lighter isotopes of the same element.
* Deuterium (the hydrogen isotope with one neutron) can form water with oxygen. This is called "heavy water" as deuterium has twice the mass of normal hydrogen (protium).
* There are 254 known stable isotopes and 80 elements which have at least one stable isotope.
* Twenty-six elements only have one stable isotope. These elements are called monoisotopic.

### Chemical bonding

The world around us is made up of tiny units of matter called atoms. How these atoms stick together to form substances is called chemical bonding.

#### Shells

Electron Shells: The electrons orbit around the nucleus of the atom. They stay in layers called shells. Each shell can only contain a certain number of electrons: the first layer can hold two electrons, the second layer eight electrons, the third layer eighteen electrons, etc.

**The Outer Shell**

All atoms would like to have a full outer shell, but the only elements to naturally have a full outer shell are the noble gases to the right of the periodic table. As a result, when atoms without full outer shells come into contact with other atoms, they tend to want to give up or gain electrons.

**Valence Electrons**

The valence electrons are the number of electrons in an outer shell of an atom that can participate in forming chemical bonds with other atoms. Atoms with a relatively empty outer shell will want to give up electrons. For example, if an atom has 1 electron out of a possible 8 in its outer shell, it will want to give up that electron, so its outer shell is now full. Atoms with a relatively full outer shell will want to gain electrons to fill up the outer shell. For example, an atom with 6 of 8 electrons in its outer shell will try to gain 2 electrons so its outer shell is full.

## Questions

* Explain atomic structure with example. Define atomic mass. Differentiate btw atomic number and mass number. Elaborate isotopes and explain isotopes of hydrogen.
* What is chemical bonding? What are electron shells? What Is the purpose of valence electrons? Differentiate btw ionic and covalent bonding. Explain co-ordinate covalent, metallic and hydrogen bonds.
* Why do atoms form chemical bonds? Which kind of energy is stored in a chemical bond? What causes chemical bonds to break during a reaction? Why are noble gases not likely to form chemical bonds? Do mixtures have strong chemical bonds? What happens to chemical bonds during chemical reactions?
* Discuss all types of electromagnetic radiations.

## Modern Materials/Chemicals

Read from Mian Shafiq’s book

### Plastic V. Polymer

Although the terms are often used interchangeably, polymers and plastics are not always the same thing. Polymers can exist organically or be created synthetically and consist of chains of joined individual molecules or monomers. Plastics are a type of polymer composed of chains of polymers which can be partially organic or fully synthetic.

Simply put, all plastics are polymers, but not all polymers are plastics.

## Questions

* What are ceramics? Discuss their properties. How are they produced? Name some of their applications. How are they classified? Explain both application-based and composition-based classification.
* Explain plastics with their properties. What are thermoplastics and thermosetting plastics? Elaborate importance and usage of plastics. Also Mention advantages and hazards of them. What do you understand by the concept ‘Plastic Waste Management’? differentiate btw polymers and plastic.
* What are fertilizers? Why are they used? Which 3 are the most imp elements that plants need to grow? Briefly explain macro and micronutrients. Fertilizers are classified on what basis? Discuss types of fertilizers on the basis of nutrient supplied and on their mode of operations. What are environmental hazards of using them? What is the solution to fertilizer pollution?
* Explain pesticides and their classification based on pest target, chemical nature and mode of entry. What are their hazards and solution to those?
* What are semiconductors? What are they made up of? Which are the common semiconductors? How many electrons do semiconductors have in their valence shells? What makes atoms to arrange themselves into structures called crystals? Explain semiconductor working with silicon atom example. What is doping? Differentiate btw N-type and P-type semiconductors. Also explain P-N junction.

# Biological Sciences

## Plastids

Plastids are double-membrane organelles which are found in the cells of plants and algae. Plastids are responsible for manufacturing and storing of food. These often contain pigments that are used in photosynthesis and different types of pigments that can change the colour of the cell.

#### Types

There are different types of plastids with their specialized functions. Among them, a few are mainly classified based on the presence or absence of the Biological pigments and their stages of development.

* Chloroplasts
* Chromoplasts
* Leucoplasts

Chromoplasts- They are the colour plastids, found in all flowers, fruits and are mainly responsible for their distinctive colours. Leucoplasts- They are colourless plastids and are mainly used for the storage of starch, lipids and proteins within the plant cell.

#### Chloroplasts

Chloroplast is an organelle that contains the photosynthetic pigment chlorophyll that captures sunlight and converts it into useful energy, thereby, releasing oxygen from water.

Chloroplasts are found in all green plants and algae. They are the food producers of plants. These are found in the guard cells located in the leaves of the plants. They contain a high concentration of chlorophyll that traps sunlight. This cell organelle is not present in animal cells.

Chloroplast has its own DNA and can reproduce independently, from the rest of the cell. They also produce amino acids and lipids required for the production of chloroplast membrane.

##### Structure

Diagram

Description automatically generated

Most chloroplasts are oval-shaped blobs, but they can come in all sorts of shapes such as stars, cups, and ribbons. Some chloroplasts are relatively small compared to the cell, while others may take up the majority of the space inside the cell.

* **Outer membrane** - The outside of the chloroplast is protected by a smooth outer membrane.
* Inner membrane - Just inside the outer membrane is the inner membrane which controls which molecules can pass in and out of the chloroplast. The outer membrane, the inner membrane, and the fluid between them make up the chloroplast envelope.
* Stroma - The stroma is the liquid inside the chloroplast where other structures such as the thylakoids float.
* Thylakoids - Floating in the stroma is a collection of sacks containing chlorophyll called the thylakoids. The thylakoids are often arranged into stacks called granum as shown in the picture below. The granum are connected by disc-like structures called lamella.
* Pigments - Pigments give the chloroplast and the plant its color. The most common pigment is chlorophyll which gives plants their green color. Chlorophyll helps to absorb energy from sunlight.
* Other - Chloroplasts have their own DNA and ribosomes for making proteins from RNA.

##### Photosynthesis

Chloroplasts use photosynthesis to turn sunlight into food. The chlorophyll captures energy from light and stores it in a special molecule called ATP (which stands for adenosine triphosphate). Later, the ATP is combined with carbon dioxide and water to make sugars such as glucose that the plant can use as food.

##### Functions

Following are the important chloroplast functions:

* The most important function of the chloroplast is to synthesize food by the process of photosynthesis.
* Absorbs light energy and converts it into chemical energy.
* Chloroplast has a structure called chlorophyll which functions by trapping the solar energy and is used for the synthesis of food in all green plants.
* Produces NADPH and molecular oxygen (O2) by photolysis of water.
* Produces ATP – Adenosine triphosphate by the process of photosynthesis.
* The carbon dioxide (CO2) obtained from the air is used to generate carbon and sugar during the Calvin Cycle or dark reaction of photosynthesis.

## Questions

## Biomolecules

### Proteins and Amino acids

Amino acids are special organic molecules used by living organisms to make proteins. The main elements in amino acids are carbon, hydrogen, oxygen, and nitrogen. There are twenty different kinds of amino acids that combine to make proteins in our bodies. Our bodies can actually make some amino acids, but the rest we must get from our food.

Proteins are long chains of amino acids. There are thousands of different proteins in the human body. They provide all sorts of functions to help us survive.

Proteins are made inside cells. When a cell makes a protein it is called protein synthesis. The instructions for how to make a protein are held in DNA molecules inside the cell nucleus. The two major stages in making a protein are called transcription and translation.

The first step in making a protein is called **transcription**. This is when the cell makes a copy (or "transcript") of the DNA. The copy of DNA is called RNA because it uses a different type of nucleic acid called ribonucleic acid. The RNA is used in the next step, which is called translation.

The next step in making a protein is called translation. This is when the RNA is converted (or "translated") into a sequence of amino acids that makes up the protein. [Discussed above](#_Translation).

#### Types

There are literally thousands of different types of proteins in our bodies. Here are a few of the major groups and functions of proteins:

* Structural - Many proteins provide structure for our bodies. This includes collagen which is found in cartilage and tendons.
* Defensive - Proteins help protect us from diseases. They make up antibodies that fight off foreign invaders such as bacteria and other toxic substances.
* Transport - Proteins can help to carry essential nutrients around our bodies. One example is hemoglobin which carries oxygen in our red blood cells.
* Catalysts - Some proteins, such as enzymes, act as catalysts to assist in chemical reactions. They help us to break up and digest our food so it can be used by our cells.

#### Functions

* Proteins build new tissues of the body and maintain and replace damaged tissues.
* Proteins carry out regulating activities as enzymes and hormones.
* Proteins are protective as antibodies.
* Proteins are responsible for movement as contractile proteins actin and myosin form basic structure of muscles.
* Keratin protein forms hair, nails, feathers, horns and beaks.
* Carrier proteins move molecules from one place to another around the body, e.g., haemoglobin.

**Sources** of protein are of both animal and plant origin. Some of the common sources are groundnuts, beans and pulses among plants and fish, egg, meat, milk and cheese among animal products.

### Lipids

Lipids are one of the four major groups of organic molecules; the other three being proteins, nucleic acids (DNA), and carbohydrates (sugars). Lipids are made up of the same elements as carbohydrates: carbon, hydrogen, and oxygen. However, lipids tend to contain many more hydrogen atoms than oxygen atoms. Lipids include fats, steroids, phospholipids, and waxes. One main characteristic of lipids is that they do not dissolve in water.

#### Types

##### Fats

Fats are composed of a glycerol molecule and three fatty acid molecules. Just like all lipids, fat molecules are made up of the elements carbon, hydrogen, and oxygen. Fat is used as energy storage in our bodies.

fats are needed by our bodies to be healthy. We couldn't live without some fats in our diet. Most people need to get around 20%-30% of their food from fats. However, too much fat can be bad for you. It can cause you to be overweight and clog up your arteries.

There are two main types of fats: saturated fats and unsaturated fats.

* Saturated Fats - Saturated fats are solids at room temperature. These fats tend to come from foods like red meat, cheese, and butter. Saturated fats are sometimes called "bad" fats because they have been known to cause higher cholesterol, clog arteries, and even increase the risk for some cancers.
* Unsaturated Fats - Unsaturated fats are liquids at room temperature. These fats tend to come from foods like nuts, vegetables, and fish. Unsaturated fats are considered much better for you than saturated fats and are sometimes called "good" fats.

##### Waxes

Waxes are similar to fats in their chemical make up, however they only have one long fatty acid chain. Waxes are soft and plastic at room temperatures. They are produced by animals and plants and are typically used for protection. Plants use waxes to help prevent water loss. Humans have wax in our ears to help protect our eardrums.

##### Steroids

Steroids are another major group of lipids. Steroids include cholesterol, chlorophyll, and hormones. Our bodies use cholesterol to make the hormones testosterone (male hormones) and estrogen (female hormones). Chlorophyll is used by plants to absorb light for photosynthesis.

Our bodies need steroids like cholesterol and cortisol to survive, so some steroids are good for us. There are also many steroids that doctors use to help sick people. However, the type of steroids you hear about in sports, anabolic steroids, can be very bad for you. They can cause all sorts of damage to your body including strokes, kidney failure, blood clots, and liver damage.

##### Phospholipids .

Phospholipids make up the fourth major group of lipids. They are very similar to fats in their chemical makeup. Phospholipids are one of the main structural components of all cell membranes.

#### Properties

General characters of lipids are:

1. Lipids are relatively insoluble in water.

2. They are soluble in non-polar organic solvents, like ether, chloroform, and methanol.

3. Lipids have high energy content and are metabolized to release calories.

4.Lipids also act as electrical insulators. They insulate nerve axons.

5. Fats contain saturated fatty acids. They are solid at room temperatures. Example, animal fats.

6. Plant fats are unsaturated and are liquid at room temperatures.

7. The melting point of fats depends on the length of the chain of the constituent fatty acid and the degree of unsaturation.

#### Functions

Lipids perform several biological functions:

1. Lipids are storage compounds; triglycerides serve as reserve energy of the body.

2. Lipids are important component of cell membranes structure in eukaryotic cells.

3. Lipids regulate membrane permeability.

4. They serve as source for fat soluble vitamins like A, D, E, and K.

5. They act as electrical insulators to the nerve fibres, where the myelin sheath contains lipids.

6. Lipids are components of some enzyme systems.

7. Some lipids like prostaglandins and steroid hormones act as cellular metabolic regulators.

8. Layers of fat in the subcutaneous layer, provides insulation and protection from cold.

9. Body temperature maintenance is done by brown fat.

10. They protect may vital organs like heart and kidney.

### Carbohydrates

When most people refer to carbohydrates they are talking about foods that are starchy (like bread, pasta, and rice) or are sugary (like candy, cookies, and cake). In science, when we talk about carbohydrates we are talking about specific types of molecules. Carbohydrates are one of the four major groups of organic molecules; the other three being proteins, nucleic acids (DNA), and lipids (fats). Carbohydrates are made up of three elements: carbon, hydrogen, and oxygen.

Carbohydrates are important to the daily lives of living organisms. They store energy (starches), provide energy for cells (glucose), and provide structure to plants and some animals.

#### Types

Carbohydrates are sometimes referred to as saccharides. The different types of carbohydrates all have the word "saccharide" in them.

* Monosaccharides - Monosaccharides are the simplest form of carbohydrates. They include sugars such as glucose and fructose. Monosaccharides often taste sweet and dissolve in water. Glucose is a common carbohydrate found in plants and is the main product of photosynthesis.
* Disaccharides - Disaccharides are formed from two Monosaccharides. They are also known as sugars such as sucrose and lactose. Lactose is the carbohydrate found in milk.
* Oligosaccharides - Oligosaccharides are formed from a small number (usually three to six) of monosaccharides.
* Polysaccharides - Polysaccharides are long carbohydrate molecules. They are often called complex carbohydrates.

There are four important types of complex carbohydrates: **Starches** - Starches are a way that many plants store energy. We can then eat starches and our bodies will use the energy. **Glycogen** - Animals use glycogen to store energy. It is stored in the liver and the muscles to be used when needed. **Cellulose** - Cellulose is used in plants as a structural molecule. It can't be digested by animals. **Chitin** - Chitin is used as a structural molecule in fungi and arthropods.

#### Functions

* Carbohydrates are chief energy source, in many animals; they are instant source energy.
* Glucose is stored as glycogen in animals and starch in plants.
* Stored carbohydrates act as energy source instead of proteins.
* Carbohydrates aid in regulation of nerve tissue and is the energy source for brain.
* Carbohydrates gets associated with lipids and proteins to form surface antigens, receptor molecules, vitamins and antibiotics.
* They form structural and protective components, like in cell wall of plants and microorganisms.
* In animals they are important constituent of connective tissues.
* They participate in biological transport, cell-cell communication and activation of growth factors.
* Carbohydrates are rich in fibre content help to prevent constipation.

**Sources:** Carbohydrates are available in wide variety of foods, for example cereals, fruits (especially dates), honey, milk, sugar beet, potato, pasta and sugarcane.

### Enzymes

Enzymes are special types of proteins. Like all proteins, enzymes are made from strings of amino acids. The function of the enzyme is determined by the sequence of amino acids, types of amino acids, and the shape of the string.

Enzymes are responsible for a lot of the work that is going on in cells. They act as catalysts in order to help produce and speed up chemical reactions. When a cell needs to get something done, it almost always uses an enzyme to speed things along.

Enzymes are very specific. This means that each type of enzyme only reacts with the specific type of substance that it was made for. This is important so enzymes don't go around doing the wrong thing and causing chemical reactions where they are aren't supposed to.

#### Structure/working

Shape, logo

Description automatically generated with medium confidence

Enzymes have a special pocket on their surface called an "active site." The molecule that they are supposed to react with fits neatly right into that pocket. The molecule or substance that the enzyme reacts with is called the "substrate." The reaction takes place between the enzyme and the substrate at the active site. After the reaction is complete, the new molecule or substance is released by the enzyme. This new substance is called the "product."

#### Characteristics

1. The basic function of an enzyme is to increase the rate of a reaction. Most cellular reactions occur about a million times faster than they would in the absence of an enzyme.

3. Most enzymes act specifically with only one substrate to produce products. For example, pepsin would only act on proteins.

4. Most remarkable characteristic is that enzymes are regulated from a state of low activity to high activity and vice versa.

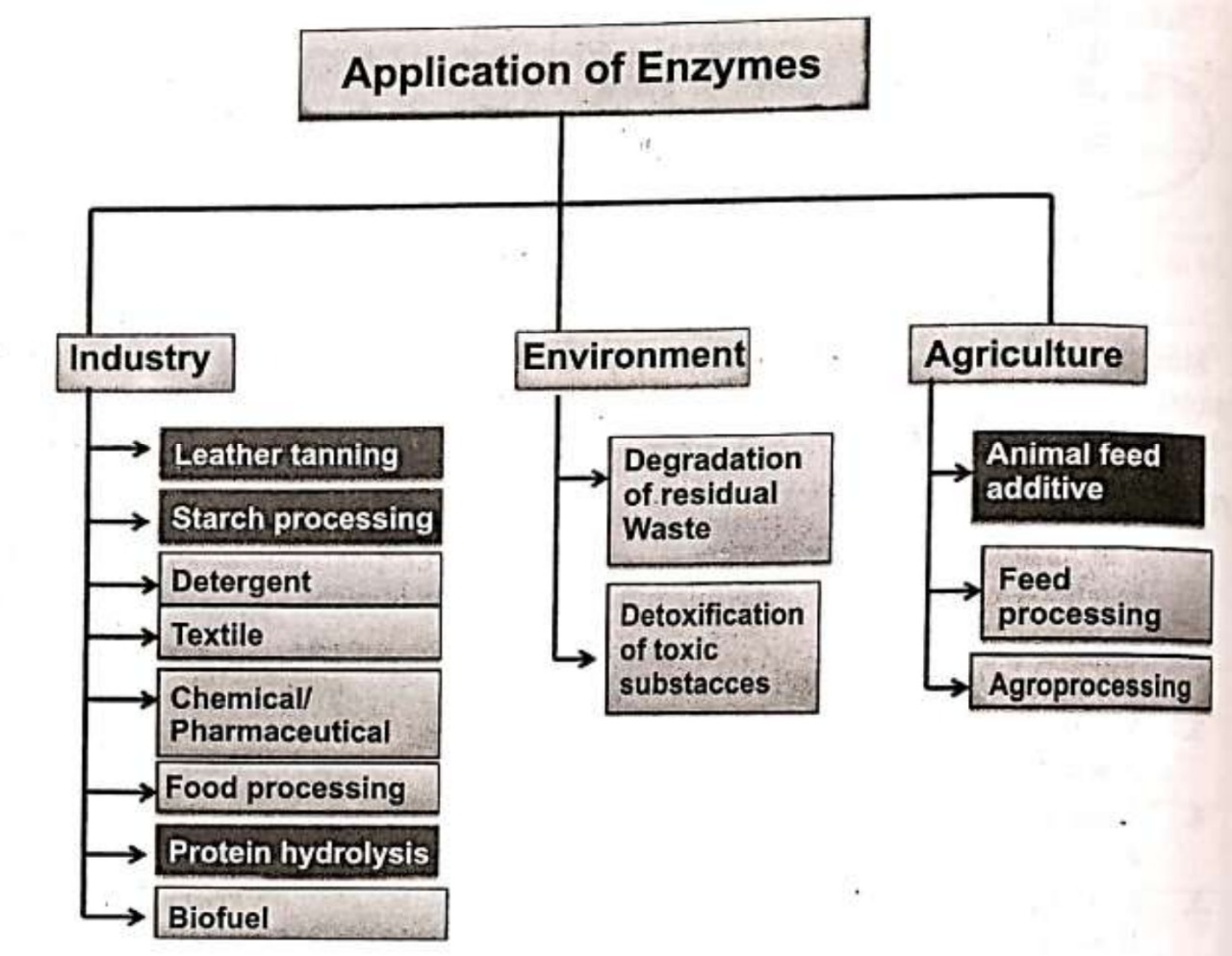
5. Enzymes are site specific; they work like a key and lock and it is called key lock It means enzymes would only attach on a specific site of the substrate.

6. Enzymes are highly sensitive to pH and temperature changes.

#### Functions of Enzymes

Enzymes perform a wide variety of functions in living organisms. They are major components in signal transduction and cell regulation, kinases and phosphatases help in this function. They take part in bodily movement with the help of the protein myosin which aids in muscle contraction. Enzymes play an important role in the digestive activity. Enzymes breakdown large molecules into absorbable molecules. Various enzymes work together in an order forming metabolic pathways, for example glycolysis.

#### Application of Enzymes



**Interesting facts**

* Enzymes don't get used up after they do their job. They can be used over and over.
* Many drugs and poisons act as inhibitors to enzymes. Some snake venoms are inhibitors.
* Enzymes are often used in industrial applications such as food processing, paper manufacturing, and detergents.
* There is an enzyme in your saliva called amylase that helps to break down starches as you chew.
* Enzymes play an important role in breaking down our food so our bodies can use it. There are special enzymes to break down different types of foods. They are found in our saliva, stomach, pancreas, and small intestine.

## Questions

* What are amino acids? What are proteins? How are they made? What are diff types of proteins? What are functions and sources of proteins?
* What are lipids? What are fats? Are all fats bad? Types of Fats? Define waxes, steroids and phospholipids. Are steroids bad for you? Properties and functions of lipids.
* What are carbohydrates? Their types? Their functions and sources?

## Plant and Animal Kingdom

## Questions

# IT

## Remote Sensing

remote means something which is not exactly in contact or in physical contact, something which is far away, the far away could be something which is slightly away or even very far away and sensing the second word means getting information, getting data getting any input; the input could be something like temperature pressure a photograph. when you look at these two terms remote-sensing normally people just think of one technology and that is the satellite remote sensing- onboard satellites orbiting around the earth which have scanners and cameras on them which are scanning the Earth's surface and drilling the images down and since it's collecting information about the Earth's surface from far away this term aptly applies to this phenomena but if you look at it in the broader sense of the word even things like your sonogram your medical imaging even even simple x-rays they are all remote sensing because you are getting information or you're getting data about things without actually being in physical contact with it so if you want it in precise as a precise definition well it's a process of measurement or acquisition of information of some property of some object or phenomena by a recording device that is not in physical or intimate contact with the object under study so that becomes the textbook definition of remote sensing due note in the definition there was no mention of satellites so who coined this term first well for that one needs to go back almost 70 years in the 1950s that Miss Evelyn Pruitt from the US Office of Naval Research give the definition she used it to describe the science and art of identifying observing and measuring an object without coming into direct contact with it

### Process

In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.

**1. Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

**2. Radiation and the Atmosphere (B)** - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

**3. Interaction with the Target (C)** - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

**4. Recording of Energy by the Sensor (D)** - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

**5. Transmission, Reception, and Processing (E)** - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

**6. Interpretation and Analysis (F)** - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

**7. Application (G)** - the final element of the remote sensing process is achieved when we apply the information, we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

### Classification

remote sensing is classified into two **active and passive** so what is active? Active is when the sensor embodies within itself the source of illumination we had cameras which used to have a built-in flash on them so the moment you click the picture the flash would fire the light from the flash would get reflected from the object and the camera would record a picture so in this case the camera is also carrying the source of illumination I have put it rather very simply

Active sensors provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated.

The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then re-emitted, as it is for thermal infrared wavelengths. Remote sensing systems which measure energy that is naturally available are called passive sensors. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded.

## Satellite navigation/GPS

GPS, or the Global Positioning System, is a global navigation satellite system that provides location, velocity and time synchronization.

US: Global Navigation Satellite Systems (GNSS). The other constellations are GLONASS developed and operated by the Russian Federation, Galileo developed and operated by the European Union, and BeiDou, developed and operated by China.

The Global Positioning System (GPS) is a navigation system using satellites, a receiver and algorithms to synchronize location, velocity and time data for air, sea and land travel.

The satellite system consists of a constellation of 24 satellites in six Earth-centered orbital planes, each with four satellites, orbiting at 13,000 miles (20,000 km) above Earth and traveling at a speed of 8,700 mph (14,000 km/h).

While we only need three satellites to produce a location on earth’s surface, a fourth satellite is often used to validate the information from the other three. The fourth satellite also moves us into the third-dimension and allows us to calculate the altitude of a device.

### Elements

GPS is made up of three different components, called segments, that work together to provide location information.

The three segments of GPS are:

Space (Satellites) — The satellites circling the Earth, transmitting signals to users on geographical position and time of day.

Ground control — The Control Segment is made up of Earth-based monitor stations, master control stations and ground antenna. Control activities include tracking and operating the satellites in space and monitoring transmissions. There are monitoring stations on almost every continent in the world, including North and South America, Africa, Europe, Asia and Australia.

User equipment — GPS receivers and transmitters including items like watches, smartphones and telematic devices.

### Working

GPS works through a technique called trilateration. Used to calculate location, velocity and elevation, [trilateration](https://www.lifewire.com/trilateration-in-gps-1683341) collects signals from satellites to output location information. It is often mistaken for triangulation, which is used to measure angles, not distances.

Satellites orbiting the earth send signals to be read and interpreted by a GPS device, situated on or near the earth’s surface. To calculate location, a GPS device must be able to read the signal from at least four satellites.

Each satellite in the network circles the earth twice a day, and each satellite sends a unique signal, orbital parameters and time. At any given moment, a GPS device can read the signals from six or more satellites.

A single satellite broadcasts a microwave signal which is picked up by a GPS device and used to calculate the distance from the GPS device to the satellite. Since a GPS device only gives information about the distance from a satellite, a single satellite cannot provide much location information. Satellites do not give off information about angles, so the location of a GPS device could be anywhere on a sphere’s surface area.

When a satellite sends a signal, it creates a circle with a radius measured from the GPS device to the satellite.

When we add a second satellite, it creates a second circle, and the location is narrowed down to one of two points where the circles intersect.

With a third satellite, the device’s location can finally be determined, as the device is at the intersection of all three circles.

That said, we live in a three-dimensional world, which means that each satellite produces a sphere, not a circle. The intersection of three spheres produces two points of intersection, so the point nearest Earth is chosen.

### Usage

Surveyors, scientists, pilots, boat captains, first responders, and workers in mining and agriculture, are just some of the people who use GPS on a daily basis for work.

There are five main uses of GPS:

Location — Determining a position.

Navigation — Getting from one location to another.

Tracking — Monitoring object or personal movement.

Mapping — Creating maps of the world.

Timing — Making it possible to take precise time measurements.

## GIS

GIS stands for geographic information system. simply put GIS is a business information management system that helps us capture analyze and present spatial information on a map GIS allows us to make better decisions using geography

### Applications

retailers use GIS to pinpoint the best locations for new stores and stock items that match local customers needs GIS is used by the conservation organizations to predict the likely consequences of global warming utilities organizations use GIS to respond promptly and efficiently to reported power outages police forces use GIS to discover patterns in criminal activity and plan operations much more strategically resulting patterns and trends can then be seen on a digital map much easier than viewing the data on spreadsheets

GIS helps the Department of Education to make sure they provide the right number of school places for children in the right locations

### Process

GIS software runs on computers ranging from the most powerful server to software on your mobile phone. in a GIS, information about the real world is stored as a collection of thematic layers linked by geography. each layer contains similar features such as streets or rivers. people can then analyze Geographic data using GIS tools and visualize geographic data as maps, graphs or charts. patterns and trends can easily be identified so information that was previously buried in a spreadsheet now comes to life. let me give you some examples retailers like Nike and levi-strauss use GIS to avoid making costly mistakes when opening new retail locations

# MISC

## Waste Management

Pakistan’s waste management landscape is in disarray. Waste management is viewed by many in Pakistan to be a public good — services that the state is obligated to provide to its citizens for free. Most residential and commercial users do not pay the government for the provision of waste management services by their municipal authorities. Any payment of garbage fees is largely confined to the residents of private housing societies and the cantonment boards. Consequently, provincial governments in Pakistan (in the absence of functioning local governments) have been grappling with a fundamental issue: how to finance the collection, transportation, and disposal of the waste produced by a burgeoning urban population?

Historically, the modus operandi of the Punjab government has been to finance the capital and operational costs of its waste management entities through grants from its budget and donor-funded programmes. These waste management entities have included government-owned Waste Management Companies (WMCs) and the Tehsil Municipal Authorities (TMA) amongst others. More recently, instead of giving outright grants, the provincial administration has changed its approach by providing “loans” to these entities. Without any foreseeable revenue streams or a change in their business model, these companies cannot be reasonably expected to return any of the borrowed amount and the provincial policymakers understand this reality well.

In the economically precarious environment of the past decade characterised by repeated periods of high inflation, the political appetite to levy any charges on the public that would further raise the cost of living has been missing. The political class would rather borrow from the future to finance today’s spending than risk their near-term electoral prospects in key constituencies. Consequently, they have had little incentive to endow the municipal waste management entities with the authority and the capacity required to enforce user charges despite knowing that the current business model is untenable.

Across the developed and developing world, it is a standard practice for municipal authorities to levy charges on their citizens for the provision of waste management services. It should be no different in Pakistan. Citizens should pay their fair share for the waste they produce through their consumption. Unless remedial measures are taken immediately, Pakistan runs the risk of mis-utilising scarce fiscal resources that are better spent elsewhere in supporting human development and welfare interventions across the country.

## Covid

Causes

Prevention

Vaccine

* Under development for decades, the RNA and DNA vaccines take a different approach to inducing immunity. Instead of injecting an antigen (whole or part of a virus inactivated) into the body, the DNA and RNA vaccines introduce a gene (in DNA vaccines) and a protein precursor (in mRNA vaccines) to produce an antigen that is found on the surface of the virus.
* The DNA vaccines work by entering the nucleus, where they transform the genes and thus present a risk; the mRNA vaccines are a small strip of amino acids that serve as a template to synthesise a protein and then disappear.

## Cloudburst

Studies have found that cloudbursts happen in an area where wildfires have happened recently. In Islamabad, we saw wildfires in the Margalla Hills just recently. The excessive heat partly caused by that wildfire could very well be responsible for the cloudburst.

Even if the Margalla Hills wildfire and the cloudburst are too far apart in time to justify the cause and effect correlation, it remains indisputable that cloudbursts occur when warm air from the ground rushes up and carries with it the falling raindrops. The result is that the rain doesn’t pour down in a steady fashion and instead causes excessive condensation in the clouds where new droplets are also formed. After reaching the maximum pressure, the cloud bursts open releasing all the rain at once.

### Causes

The warm air that caused the cloudburst, the wildfires in Margalla Hills, the excessive heat that Islamabad experienced are all the result of those very cars that we so fondly own and drive. The combustion of the oil inside the engines of those cars releases an enormous amount of carbon that accumulates into the atmosphere creating excessive warming.