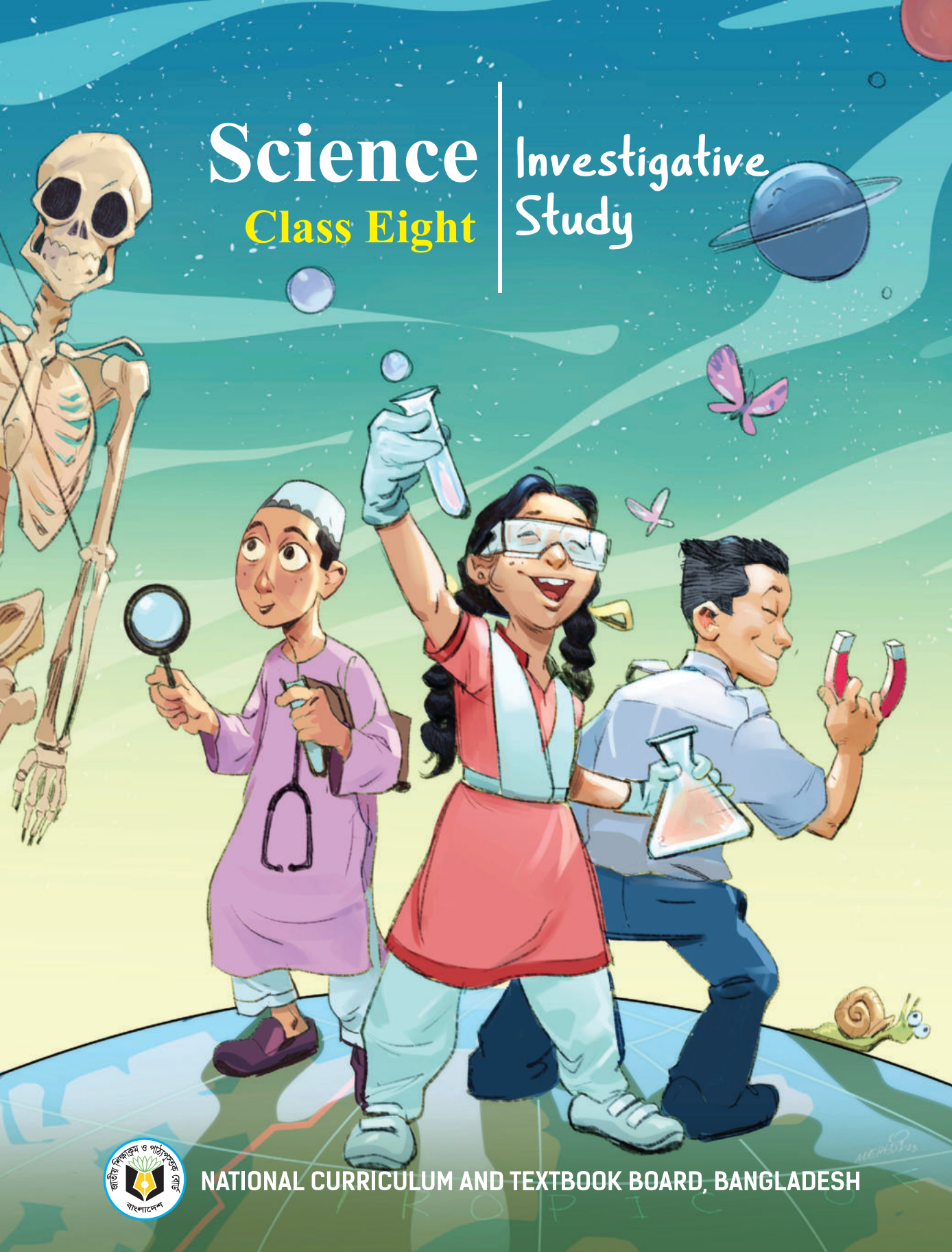
Science

Class Eight

Investigative Study



NATIONAL CURRICULUM AND TEXTBOOK BOARD, BANGLADESH

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১৯৪৭ সাল থেকেই পাকিস্তানি শাসকগোষ্ঠী দ্বারা পূর্ব পাকিস্তানের (বর্তমান বাংলাদেশ) জনগণ সর্বপ্রকার অত্যাচার, শোষণ, বৈষম্য ও নিপীড়নের শিকার হয়েছে। ১৯৭১ সালের ৭ই মার্চ বাংলাদেশের স্বাধীনতা সংগ্রামের অবিসংবাদিত নেতা বঙ্গবন্ধু শেখ মুজিবুর রহমান স্বাধীনতার ডাক দেন এবং ২৬শে মার্চ আনুষ্ঠানিকভাবে স্বাধীনতার ঘোষণা প্রদান করেন। ৯ মাসের মুক্তিযুদ্ধে অংশ নেয় নারী-পুরুষ, হিন্দু-মুসলিম, বৌদ্ধ-খ্রিষ্টান, শিশু-কিশোরসহ সর্বস্তরের জনগণ। পাকিস্তানি সেনাদের পাশবিক নির্যাতনের শিকার ২ লাখের অধিক মা-বোনের ত্যাগ এবং ৩০ লক্ষ বাঙালির প্রাণের বিনিময়ে সশস্ত্র সংগ্রামের মাধ্যমে ১৯৭১ সালে ১৬ই ডিসেম্বর মুক্তিবাহিনী ও ভারতীয় বাহিনীর যৌথ কমান্ডের কাছে পাকিস্তানি হানাদার বাহিনীর আত্মসমর্পণের মধ্য দিয়ে মুক্তিযুদ্ধে বিজয় অর্জন করে বাংলাদেশ। বিশ্ব ইতিহাসে বাংলাদেশের মুক্তিযুদ্ধ খুবই তাৎপর্যপূর্ণ ঘটনা। বাংলাদেশ তৃতীয় বিশ্বের প্রথম দেশ, যে দেশ সশস্ত্র মুক্তিযুদ্ধের মাধ্যমে স্বাধীনতা অর্জন করেছে।

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Science

Investigative Study

Class Eight

(Experimental Version)

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PREFACE

In this ever-changing world, the concept of life and livelihood is changing every moment. This process of change has been accelerated due to the advancement of technology. There is no alternative to adapting to this fast changing world as technology is changing rapidly ever than before. In the era of fourth industrial revolution, the advancement of artificial intelligence has brought about drastic changes in our employment and lifestyles that will make the relationship among people more and more intimate. Various employment opportunities will be created in near future which we cannot even predict at this moment. We need to take preparation right now so that we can adapt ourselves to that coming future.

Although a huge economic development has taken place throughout the world, problems like climate change, air pollution, migrations and ethnic violence have become much more intense nowadays. The breakouts of pandemics like COVID 19 have crippled the normal lifestyle and economic growth of the world. Thus, different challenges as well as opportunities, have been added to our daily life.

Standing amid the array of challenges and potentials, sustainable and effective solutions are required to transform our large population into a resource. It entails global citizens with knowledge, skill, values, vision, positive attitude, sensitivity, adaptability, humanism and patriotism. Amidst all these, Bangladesh has graduated into a developing nation from the underdeveloped periphery and is continuously trying to achieve the desired goals in order to become a developed country by 2041. Education is one of the most crucial instruments to attain the goals. Hence, there is no alternative to the transformation of our education system. This transformation calls for developing an effective and updated curriculum.

Developing and updating the curriculum is a routine and important activity of National Curriculum and Textbook Board. The curriculum was last revised in 2012. Since then, more than a decade has elapsed. Therefore, there was a need for curriculum revision and development. With this view, various research and technical studies were conducted under NCTB from 2017 to 2019 to analyze the current state of education and identify the learning needs. Based on the researches and technical studies, a competency-based and seamless curriculum from K−12 has been developed to create a competent generation capable of surviving in the new world situation.

Under the framework of this competency based curriculum, the textbooks have been prepared for all streams (General, Madrasah and Vocational) of learners for Class Eight. The authentic experience-driven contents of this textbook were developed with a view to making learning comprehensible and enjoyable. This will connect the textbooks with various life related phenomenon and events that are constantly taking place around us. It is expected that, through this, learning will be much more insightful and lifelong.

In developing the textbooks, due importance has been given to all − irrespective of gender, ethnicity, religion and caste while the needs of the disadvantaged and special children are taken into special considerations.

I would like to thank all who have put their best efforts in writing, editing, revising, illustrating and publishing the textbook.

If any errors or inconsistencies in this experimental version are found or if there is any suggestions for further improvement of this textbook, you are requested to let us know.

Professor Md. Farhadul Islam

Chairman

National Curriculum and Textbook Board, Bangladesh

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A few words for the students-

Students, how are you all? Welcome to the Science subject of Class Eight.

You can see, there is going to be a big change in the way you have been studying for so long! Your books on all subjects are also a little different this time. You must have got two books on Science! Along with this 'Investigative Study' book you are given another 'Exercise Book'. If you have a look, you will realize that there is a big difference between this book and the Exercise book. Honestly speaking, the way you used to try to learn science by reading different chapters of textbooks, now this way of learning is completely changing. Throughout the year, you will go through several new experiences, solve some new problems. These new experiences and problem solving steps are detailed in your work book. In solving these problems, you will need to know different aspects of science at different stages. This 'Investigative Study' book will help you in this regard. At school or at home, wherever you are, you can use this book to solve problems yourself if needed!

This book covers the topics of Science that you will need to know in Class Eight. The topics are organized in Sixteen chapters. Many of these things will be useful to you at different times in the experiences that you will go through throughout the year.

So let us start, what do you say?

CHAPTER 1

STUDY OF MOTION

CHAPTER 1 STUDY OF MOTION

This chapter deals with the following topics:

- ☑ Basics of Displacement
- ☑ Basics of Velocity
- ☑ Basics of Acceleration
- ☑ Linear and Circular Motion
- ☑ Equations of Motion
- ☑ Graphs of Motion

1.1 Distance and Displacement:

To discuss the motion of an object, we find the change in the object's position with time. The change in position can occur in various ways—fast or slow, straight or curved, uniform or non-uniform, etc. Regardless of how the motion occurs, to explain it, we need to precisely measure the position of our object with respect to time. To do this, we need a fixed point in relation to which we will measure the position. Finding a truly fixed point is not easy; on Earth, we can consider the Earth's center as relatively fixed, but the Earth itself not only spins on its axis but also revolves around the Sun. Our entire solar system, in turn, revolves around the center of our galaxy and the entire galaxy is moving due to the expansion of the universe. However, for our everyday tasks, we can take any nearby point as a relatively fixed point and measure the position of an object relative to that point.

When we specify a reference point, we can measure the position of an object relative to it. Imagine in a field, a goat is tied to a post. Here, the post is the reference point. If we say that the goat is two meters away from the post, it does not specify exactly where thegoat is. This is because the goat could be in any direction two meters away from the post! If we say that the goat is two meters south of the post, then with respect to the reference point, you can precisely say where the goat is located. In other words, to know the position of an object, we need to know both the 'direction' and 'distance' from the reference point.

To discuss the motion of an object, it is necessary to understand two quantities in addition to the position of the object—'Distance' and 'Displacement.' In the case of a moving object, the amount of ground it covers is known as 'distance,' which can be along a straight line or a curved path. Distance has a quantity, but no direction. On the other hand, in scientific terms, 'displacement' is a measure of how far an object has moved from its initial position. If you go 10 kilometers north and then return 5 kilometers south, the total distance covered is 15 kilometers, but the displacement is only 5 kilometers north. Displacement always specifies the direction. The picture below provides some examples of distance and the calculated displacements for those same distances.

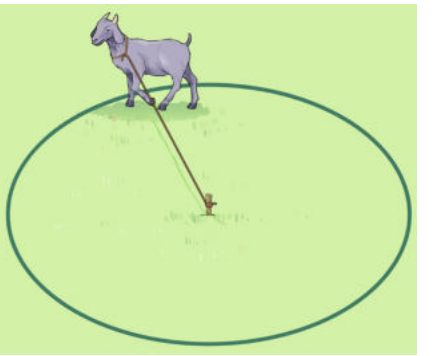


Figure: How much distance would the goat travel if it circles the pole and returns back to its starting position?

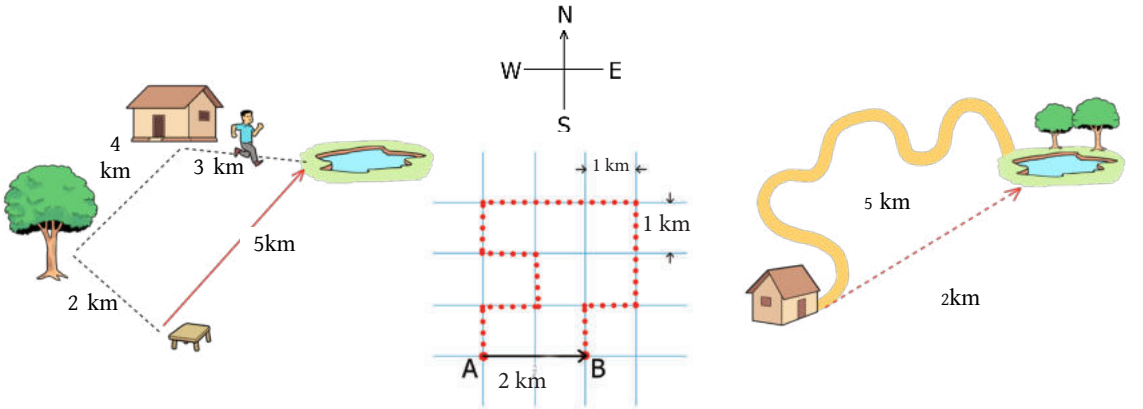


Figure:

(a) In the left image, a boy walks 2 km from his starting position and reaches a tree, then changes direction, walks 4 km and reaches a house. He changes his direction again and walks 3 km to reach a waterbody. He travels a distance of (2 + 4 + 3 =) 9 km in total. The displacement of the waterbody from his starting position is 5 km in the direction pointed by the arrow.

(b) In this image, we can see parallel roads every 1 km both along the north-south and east-west directions of the town. A person drives a car along the roads from point A to point B, travelling a distance of 12 km with a displacement of 2 km towards the east.

(c)The distance of the waterbody from the house is 2 km in the direction indicated by the arrow

Food for Thought: 'The magnitude of displacement is distance'—is this statement correct or incorrect?

1.2 Speed and Velocity

If you look around you, you will see vehicles like cars, buses, bicycles, or pedestrians moving on the road. However, they are not all moving in the same way. Some are moving quite fast, while others are moving slower. To express this in a scientific way, we use the terms 'speed' and 'velocity'. First, let's learn what speed means. We have just become familiar with two quantities, distance and displacement. The amount of distance covered in unit time is known as speed. In other words, if an object travels a distance of d in time t, then its speed v is:

$$v=d/t$$

Since there is no specific direction for distance, speed also does not have a specific direction; it only has a magnitude.

- Distance refers to the length of space an object has travelled. We use units like inches, feet, centimeters, meters, etc. to measure distance.
- When we determine the amount an object moves in a particular direction, we call it 'displacement'. To denote displacement, we use measurements such as two kilometers north, five feet to the right, three centimeters upward, seven meters forward, etc.

Example: We didn't specify how long it took to travel the mentioned distances in the examples of the previous image. Let's assume that it takes 2 hours, 30 minutes and 1 hour to travel distance (a), (b) and (c) respectively and calculate the speed for each.

(a) 9 km is travelled in 2 hours, so speed:

$$v = \frac{9\ km}{2\ hour} = 4.5\ km/h$$

(b) 12 km is travelled in 30 minutes, so speed:

$$v = \frac{12\ km}{30\ minutes} = \frac{12\ km}{0.5\ hour} = 24\ km/h$$

(c) 5 km is travelled in 1 hour, so speed: 5 km/h

As you can see, when determining the speed of an object, we do not need to consider the direction of its motion.

However, here you have to remember that this speed is the average speed of the total time. We don't know the instant speed at any individual moment in these cases. If in any special cases the object moves at a uniform speed, only then the magnitude of its average speed and instant speed can be the same.

If we understand the concept of speed properly, then we can easily understand what velocity is. If the direction of a moving object is specified along with its speed, then that's called velocity. In other words, the distance travelled by an object in unit time to a specific direction is called velocity. Therefore, to calculate the velocity of an object, we need to specify the magnitude as well as its direction. If we only consider motion along a straight line without any deviation, then there is no difference between speed and velocity. In that case, the magnitude of the velocity is called speed.

Can you recall that when we learnt about speed, we divided the traversed distance by time to obtain the average speed over that time period. This is true for velocity too. When we calculate the velocity of an object moving in a specific direction, we get the average velocity during that time, not the instant velocity of any individual moment. The value of the average velocity will be the same only if the object is moving at a uniform velocity.

Remember, when an object changes direction in motion, calculating its average can confusion us. Suppose an object returns to the exact same point from where it initially started; then, the total displacement of the object is zero. Therefore, when we divide the total displacement by the total time to calculate the average velocity, its magnitude becomes zero, even though the object's velocity was never zero when it was in motion!

1.3 Acceleration and Deceleration

We have all observed various types of motion around us. Some are going straight, some along a curved path, some are circular or maybe even oscillating up and down. However, we are going to confine our discussion here to the simplest of the motions—motion along a straight line. Within this motion, there is no difference between speed and velocity. Moreover, since it is moving along a straight line, the direction of the motion here is also specific. Therefore, when we talk about velocity in this section,

there is no need to mention the direction of it separately.

The change in the speed of a moving object, either increasing or decreasing, is a very familiar thing. You have certainly experienced situations where the speed of a bicycle, car, bus, or train you were on increased gradually from a stationary position, or even the opposite happened, meaning the speed gradually decreased. The process of changing velocity over time is called acceleration when it increases and deceleration when it decreases.

We used 'displacement' to measure changes in position. We measured how fast or slow the displacement is happening to get 'velocity'. When we determine the amount of change of this varying velocity with time, we get acceleration or deceleration. In other words, the change of velocity in unit time is called Acceleration. If the initial velocity of an object is u, the final is v after time t, then its acceleration a is:

$$a = \frac{v - u}{t}$$

Similar to velocity, we need to specify both the magnitude and direction of an acceleration.

» The amount of change in velocity per unit time is called 'acceleration'. We express acceleration as 2 m/s^2 (read as two-meter-per-second-square) eastward, or 9.8 m/s^2 downward, etc. If the final speed is greater than the initial speed, that is, if the velocity increases or the change is positive, then it is positive acceleration. If the final velocity is less than the initial speed, the velocity decreases or changes negatively, and that is called negative acceleration. Negative acceleration is often called 'deceleration'.

1.3.1 HOW DOES ACCELERATION HAPPEN?

We have learnt so far that we can determine acceleration or deceleration by measuring the increase or decrease in velocity over a specified time. However, we haven't yet discussed why and how acceleration occurs, or in other words, why there is a change in velocity. We regularly see changes in velocity in our daily lives. If you sit still for a while and then start walking, your velocity changes. When a bus or train starts moving, its velocity changes. When you start pedaling a bicycle, you change your velocity. Even when a reckless motorbike rider crashes a bike into a light-post, causing it to fall and stop, there occurs a change in velocity.

If you think for a moment, you will understand that a change in velocity never happens on its own; there is always a cause for it. The cause behind changing velocity is application of force. Without applying outside force, you can never change the velocity of an object. To ride a bicycle, we apply force on the pedals; for buses or trains, their engines applies force when they are started; and in the case of our reckless motorbike rider, the light-post applied force on the bike and stopped it.

Now, let's try to understand what is meant by ‘Force’. The simplest example of applying force is pushing or pulling something. Another example is when an object is dropped from above, it tends to fall downward due to another force called gravity. Those of you who have played with magnets have undoubtedly seen the magnet attracting iron, which happens due to a type of force known as magnetic force. In cold weather, when you rub a comb against your hair, you can attract small pieces of paper by it; this is a type of force called static electric force. If you roll something on the ground, it rolls for a while and then stops. The force that stops it is known as frictional force. So, if you keep your eyes and ears open, you will discover many types of forces around you in various situations.

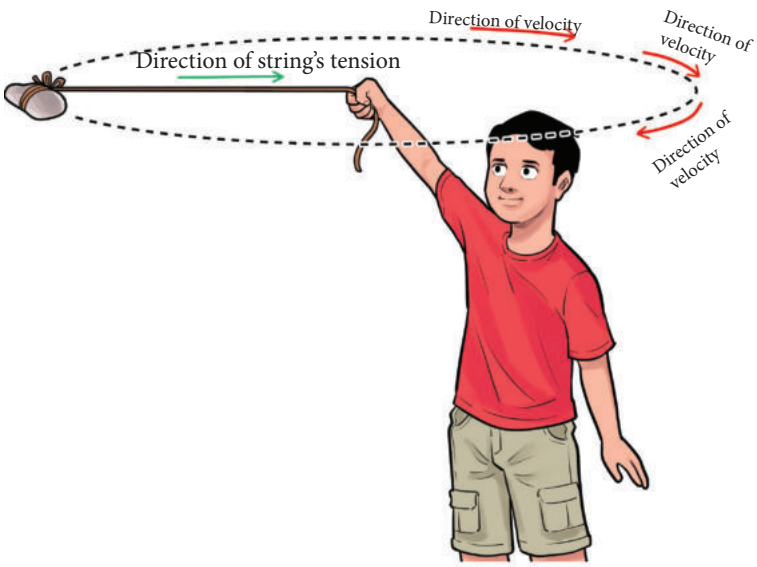
However, the most important role of force is that whenever there is a need to change the velocity of an object, we must apply force there. Without applying force, you will never be able to change the velocity; neither increase it nor decrease it. Alternately, it is also true that if you ever see a change in a velocity, you can be certain that force has definitely been applied there.

Now I put forward an important question to you. If the speed, or the magnitude of a velocity changes, then inevitably the velocity changes. That means without applying force, we cannot change the magnitude of velocity or speed. Speed does not have a specific direction, but velocity does. So, if we change only the direction of a moving object, does that change its velocity? Moreover, if nothing else changes except the direction of an object, can we call it acceleration?

1.3.2 ACCELERATION IN CURVED PATHS

If we tie an object with a string and spin it around as shown in the picture, does that object experience any acceleration? If there is acceleration, what is its value?

The rate of change of velocity with time is acceleration. An object rotating on a circular path changes its direction with respect to its 'direction' every moment, meaning its velocity also changes every moment. Therefore, an object rotating on a circular path



Rotating objects moving on a circular path has an acceleration towards the center

is an excellent example where there is no change in the object's speed, but there is a change in velocity. Hence, there must be an acceleration here. We know that acceleration is created by applying a force on an object.

Those of you who have tried to spin an object tied to a string, as shown in the picture, know that you have to apply a force by holding it with your hand or by applying a force directed towards the center. The force applied here creates a certain acceleration. To explain the motion of this rotating object, we only need two quantities: the length of the string (which is actually the distance from the center) and the velocity of the object. Therefore, the acceleration is definitely dependent on these two quantities. If we knew a little bit of Calculus, we could easily determine the equation of this acceleration. However, since you haven't had the opportunity to learn Calculus yet, we better just give you the answer. If the velocity is v and the length of the string is r, then the centripetal acceleration a is:

$$a = \frac{v^2}{r}$$

If we learn and remember this simple relationship, we will be able to discover many fascinating stuffs in science using this. You will see that just by using this one formula, without knowing anything else, you can calculate the height at which the Bangabandhu Satellite orbits the Earth!

1.4 Equations of Motion

You have studied 'Linear Equations' in the previous grade. In this chapter, we will learn to form equations of motion using displacement, velocity, and acceleration. We will still be only discussing motion in a straight line here.

1.4.1 EQUATION OF VELOCITY

Let's assume the initial velocity of an object was u, and due to the presence of acceleration, the velocity of the object has increased to v after a time t. So, as we have learnt already, the equation for the acceleration of the object is:

$$a = \frac{v - u}{t}$$

No matter how simple it may seem, it is still an equation. Since the values on the left side and the right side are equal, we can interchange the left and right sides if we want and write it as:

$$\frac{v - u}{t} = a$$

Now, multiply both sides by t:

$$\frac{v - u}{t} \times t = a \times t$$

So, the equation becomes: $v - u = at$

Now, adding u on both sides, we get,

$$v = u + at$$

This is the first equation of motion. If you know the initial velocity and acceleration of an object, you'll be able find it's velocity after a certain time using this equation. Now, let's see how we can use it to perform various calculations.

Example: An engine of a car creates an acceleration of 2 m/s². If at any moment you observe the car moving with a velocity of 3 m/s, what will be its velocity after 4 s?

Answer: Here, let's first examine what information we have. The acceleration of the car is 2 m/s², denoted by a. Initially, it is moving with a velocity of 3 m/s, denoted by u. We

have given a time of 4 s, denoted by t, and we want to find the changed velocity after this time, that is, we have to find v.

Therefore, we have learned that, $v = u + at$

$$v = 3 + 2 \times 4 = 11 \ m/s$$

Hence, the calculation shows us that after 4 seconds, the car will have a velocity of 11 m/s.

1.4.2 EQUATION OF DISPLACEMENT

The first thing we generally seem to know about a moving object is how much distance the object has travelled in a certain time. If an object moves with a constant velocity, we can obtain the traversed distance simply by multiplying the velocity with time. In other words, if the velocity of the object is V and it stays in motion for time t, the distance travelled or the displacement s is:

$$S = Vt$$

However, if the object has an acceleration, it means it does not have a constant velocity. In that case, we cannot use this simple formula anymore. But if the object moves with a uniform
acceleration, we can substitute the velocity in the above formula by the average velocity. At first, let's find the average velocity V:

$$V = \frac{u + v}{2}$$

We also just derived another equation of v in the last section. Let's put that in here:

$$V = \frac{u + (u + at)}{2}$$

Therefore, average velocity V is:

$$V = u + \frac{1}{2} at$$

Since, distance travelled is S=Vt, so we can write:

$$S = (u + \frac{1}{2} at) \times t$$

Or,

$$S = ut + \frac{1}{2} at^2$$

We have derived another important equation of motion. Now, let's try using it to perform calculations.

Example: How far will the car from the previous example travel after 4 s?

Answer: From previous example, we get, acceleration of the car a = 2 m/s2, initial velocity u = 3 m/s, amount of time t = 4 s. We have to calculate the displacement s.

We learnt that,

$$S = ut + \frac{1}{2} at^2$$

$$S = 3 \times 4 + \frac{1}{2} \times 3 \times 42$$

$$= 12 + 16 = 28\ m$$

Hence, according to the calculation, in 4 s the car will travel a distance of 28 m.

1.4.3 THIRD EQUATION OF MOTION

In the previous two equations, we had the variable t representing time. But what if we don't have a anything to measure time? To use such cases, let's combine these two equations to derive a new equation that eliminates the need to know t. We can start with the equation v=u+at, where t is present on the right-hand side. And in the equation

$$S = ut + \frac{1}{2} at^2$$

we have t^2 on the right-hand side. So, we can assume that squaring the equation v=u+at may give us some insights.

Let's start by squaring both sides of the equation:

$$v^2 = (u + at)^2$$

বা, $v^2 = u^2 + 2uat + a^2t^2$

বা, $v^2 = u^2 + 2a \, . \, ut + 2a \, . \, ½ \, at^2$

বা, $v^2 = u^2 + 2a \, (\, ut + ½ \, at^2 \,)$

Since, $S = ut + ½ \, at^2$, we can now use this so form the following equation of motion without the variable t in it:

$$v^2 = u^2 + 2aS$$

Remember this simple equation, because it contains some fascinating scientific insights we've yet to reveal!

Now it's time to continue to calculations using this formula.

Example: A stone is falling with an acceleration of 10 m/s². Starting with an initial velocity of 2 m/s, it covers a distance of 3 m. What is its final velocity?

Answer: Here, A stone has an acceleration a = 10 m/s², an initial velocity u = 2 m/s and a displacement s = 3 m. We need to calculate the final velocity v.

We have learnt that, $v^2 = u^2 + 2aS$

$v^2 = 2 \times 2 + 2 \times 10 \times 3 = 4 + 60 = 64 = 8^2$

$v = 8$ m/s

Hence, according to the calculations, after travelling a distance of 3 m, the final velocity of the stone will be 8 m/s

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Food for Thought : Is it possible to derive the equation $v^2 = u^2 + 2aS$ if we find a formula for t from the equation v=u+at, and then put that formula in the equation $S = ut + ½ \, at^2$?

1.4.5 GRAPH OF EQUATIONS OF MOTION

We have derived three equations and used them to perform some calculations. At this point, we learn another important technique, which is expressing equations through graphical representations. The process of plotting graphs will be explained in your exercise book and then you'll have another method in your bag for solving scientific problems. In this chapter, we have provided three graphs corresponding to the three equations of motion derived earlier. You can estimate a lot of information from these graphs.The first graph demonstrates how an object's velocity along a straight line changes with time. The values for the initial velocity (u) and the acceleration (a) are given above the graph. If they were not given, we could determine these values from the graph itself. For example, we can see from the graph that when the time is zero, the velocity is 10 m/s, which means this is the initial velocity (u). Similarly, the graph shows that in 15 seconds, the velocity has increased from 10 m/s to 40 m/s. Therefore, the acceleration a can be calculated as follows:

The other two equations of motion are shown in the following graphs. You will notice that when the displacement is given with respect to time, it does not increase linearly but follows a square-proportional relationship on a graph.

By using the equations

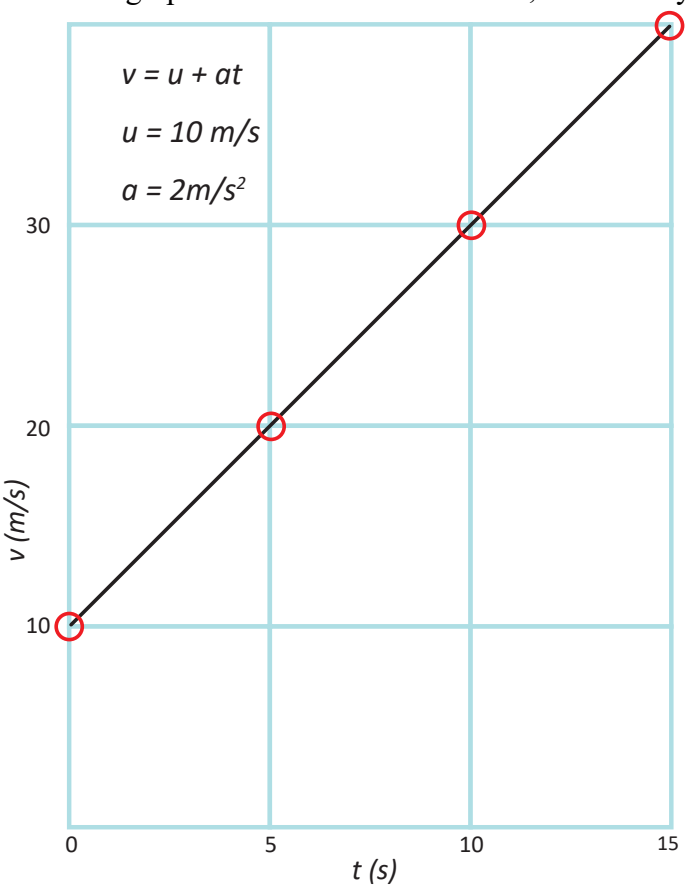


Figure: This graph shows the magnitude of velocity (v) with respect to time (t).

of motion, you determined the value of a specific quantity at a given time or for a specific displacement. However, a graph provides you with more than just one value of a quantity at a time, rather it lets you calculate an approximate value for any point on the axis below!

Food for thought : Can you estimate the magnitude of velocity after 7.5 seconds from the first graph? Can you estimate the displacement travelled in 3.5 seconds from the second graph? Can you estimate the velocity of an object when it has travelled a distance of 25 meters from the third graph? As you can see, even if you cannot determine the exact values, you can get reasonably close estimates from these graphs.

Remember, the ability to estimate near approximate values of quantities is an important skill when learning science.

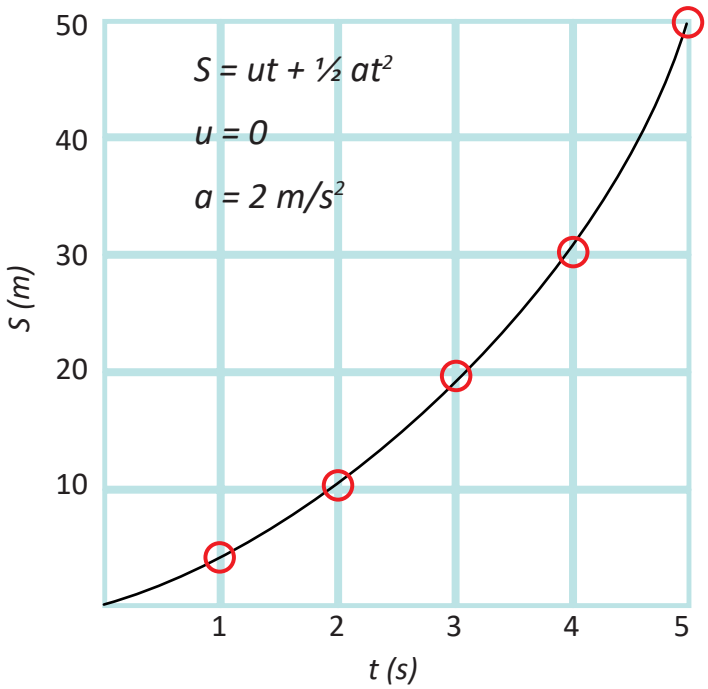


Figure: The above graph shows the value of displacement (S) with respect to time (t),

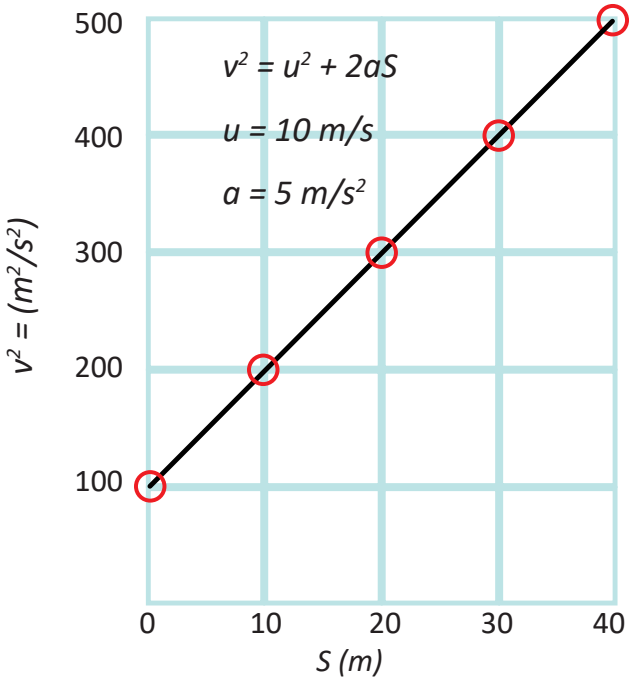


Figure: The above right graph, the square of velocity (v^2) is shown with respect to displacement (S).

Chapter 2

Energy

Chapter 2 Energy

This chapter deals with the following topics :

- ☑ Work and Energy
- ☑ Concept of Potential Energy
- ☑ Concept of Kinetic Energy
- ☑ Relationship between Mass and Energy
- ☑ Concept of Power

2.1 Work and Energy

We all have seen that an object can be moved by applying force. The amount of the completed work depends on the amount of the applied force and the distance over which the object is moved. We use the word 'work' in our daily conversation, in the scientific term, the word 'work' has a specific meaning. If an object is displaced in the direction of the force by applying a certain amount of force, only then it is considered that work has been done. Imagine, you have moved a brick ८ metres by giving it a push, while your friend has pushed the same brick with the same amount of force and has moved it १० metres. Both of you have applied the same amount of force, but you have done different amounts of 'work' by 'moving the brick' to different distances. In the same way, even if both of you pushed the brick to move it to the same distance, but with different amounts of force, the amount of completed work would be different. In other words, in order to determine the amount of work, both quantities, that is, force and displacement are necessary. In mathematical terms, it can be said that work is the product of force and displacement.

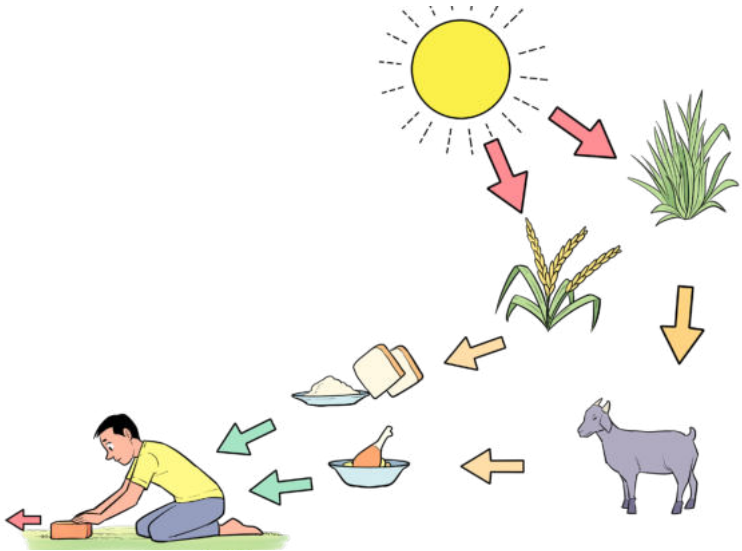
Work = Force × the displacement produced in the direction of force

Or, $W = F \times S$

The unit of work is the Joule, It is expressed as J.

Energy is needed to work. We are all familiar with the word force. In our everyday

conversation, we refer to the application of energy or the application of force as same. But in science terms, the word energy has a specific meaning. The ability to do work is called energy. Energy cannot be created or destroyed; one form of energy can only be transformed into another form of energy. In academic term, this is known as the conservation of energy. The transformation of energy from one form to another is called conversion of energy.A little while ago, you have been told about working while moving bricks by applying force. The ability for this work came from your hands. The energy in your hands has come from the chemical energy stored in your body. The chemical energy has come from food. If you have eaten rice or roti, those have come from paddy or wheat plants. If it's meat, it has come from some animals like chickens or cattle or goats. Animals have also grown up eating grass, leaves, or straw. The energy of grass, leaves, or other trees has come through the process of photosynthesis. Photosynthesis requires light, which comes from the Sun. The Sun gets its energy from a continuous nuclear reaction called fusion. Thus the transformation of energy from one form to another continues.



Continioous Transfer of Energy

Since energy is the amount of work, its unit is also the joule.

2.2 Potential Energy

We have already known various examples of energy. We have also known that the ability to do work is actually energy. There are some forms of energy that can be stored through the performance of work. For example, an elastic band or rubber band can be stretched and released, which can be used to throw something, similar to a slingshot. The same type of work can be done with a spring, by stretching or compressing it. A spring or rubber band does not stretch or compress on its own, but external force needs to be applied to make it stretch. The work performed to stretch work is stored within

The potential energy stored in the bow shoots the arrow. During the liberation war, the people of this country fought with bows and arrows along with modern weapons.

the spring in the form energy. If you want to place an object on a table, you have to pull it up. It means, you have to apply force on the object to lift it on the table. We know from the definition of work that work is done when an object is lifted by an upward force. After placing this object on the table, if you bring it to the corner and release it, the object will fall down by itself, you do not need to drag it down. If the object falls on a spring, the spring will be compressed and shortened. We have already known that in order to shorten (or lengthen) the spring, an external force must be applied. That is, while falling from above, an ability or force is created in the object to do work. Where does this energy come from? When the object was initially lifted up by 'working' on the object, that work has been stored as energy in the object. If the object is brought to the edge of the table and released, it will fall down due to the force of gravity. You know that the source of gravity is the earth, it pulls everything down.

Thus, from some examples, we have learnt that when we do 'work' by applying force on certain objects, that work can be stored as energy. In the term of science, the general name for this energy is 'potential energy'. In the case of spring, this energy has come from the work done against the 'elastic' behaviour of the object. That's why it is called 'elastic potential energy'. On the other hand, the energy in the object lifted onto the table came from the work done against 'gravity'. Therefore, it is called 'gravitational potential energy'.

Therefore, we see that when we lift something up, potential energy is stored within it. But is it possible to know how much potential energy is stored in it? In fact, it is not a difficult job. The amount of work done on the object is the same as the potential energy stored. We also know how to measure the amount of work. The amount of work done can be measured by multiplying the amount of force applied and the amount or distance lifted up.

Let's, at first, determine the amount of the force. Objects fall downwards just because they have weight. If we don't apply a force of exactly the same weight of the object in the upward direction, the object cannot be lifted up. In the discussion on the mass of an object in the previous class, you were informed that weight is the same as the force of gravity acting on an object. That is to say, the greater the mass of an object, the greater its weight. When you will study about the gravitational force, you will see, if the mass of an object is m kg, then we get the weight of that mass by multiplying it by 9.8 m/s^2. Not only that, you will see that this number, 9.8 m/s^2, has not come out of nowhere; this number is the acceleration due to the force of gravity.

This acceleration is called the gravitational acceleration or the acceleration due to gravity and is abbreviated as g.

Now we will be able to calculate the gravitational potential energy:

Gravitational potential energy = Work done against gravitational force

= Gravitational force × displacement

= Weight × displacement

= Mass × gravitational acceleration × displacement

Now, if we express gravitational potential energy as 'E', mass as 'm', gravitational acceleration as 'g', and displacement as 'h', it can be written as: $E = mgh$

That is, if an object of mass m is lifted up to a height h, potential energy mgh will be stored in it. From this it is understood that the higher we lift the brick, the more work will be done i.e. the more 'energy' will be stored.

2.3 Keinetic Energy

Let's go back to the example of pushing a brick by applying a force. Imagine there is a brick of mass m on a table, and you have pushed it a distance of s with a force F. Therefore, the amount of work we have is W=FS. However, we have learnt so far that when work is done on an object, the work is stored as energy. But after pushing the brick, we don't see any sign of stored energy anywhere! If we lifted the brick to a height h instead of pushing it horizontally, then the work w done would be stored as gravitational potential energy with at least an amount of mgh.

If you think a little, you will understand that the work was not wasted. When you pushed the brick rubbing across the floor, the friction created heat, and maybe some noise was also produced. Thus, the work you had done was transformed into thermal energy or sound energy. Due to the conservation of energy, it must be transformed in some form or another

Now imagine that you have somehow created a completely frictionless floor where no friction occurs to push a brick. On this floor, if you push a brick of mass m to a distance d with a force F, your work will not transformed into any thermal or sound energy. Then where will we find the energy that the work has generated? If you think a bit, you will understand that when you apply a force, the object will experience acceleration and its velocity will increase. When you release the brick, it will continue to move at this velocity without slowing down.

The energy generated inside an object for its velocity is called kinetic energy, and the energy we are familiar with in our daily lives is probably this kinetic energy. For example, if you place a hammer on a brick, nothing happens to the brick. But if you bring the hammer down too fast with a strong velocity, the brick may shatter into pieces. There is no force inside a stationary hammer but there is a lot of energy within a moving hammer. If we want, we can also determine the quantity of kinetic energy generated for a given velocity. To do that, we need to know the acceleration of a mass when a force is applied to it. When we figured out the gravitational potential energy we observed that the weight or gravitational force is mg,

where m is the mass and g is the gravitational acceleration. This applies not only to gravitational force or acceleration but to all forces and accelerations. Therefore, if a force F is applied to an object with mass m, then its acceleration a can be determined by the following formula:

$$F = ma$$

Now, we can determine the amount of kinetic energy E generated inside an object for the work W.

Kinetic energy = work done on an object

Or, $E = W$

If a force F is applied to the object and it moves a distance S, then the amount of work done is $W = FS$.

So, $E = FS$

Substituting $F = ma$, $E = maS$

We observed in the third equation of motion: $v^2 = u^2 + 2aS$ and it was mentioned that within this equation, there lie some fascinating scientific discoveries waiting to be uncovered. This time it will come out!

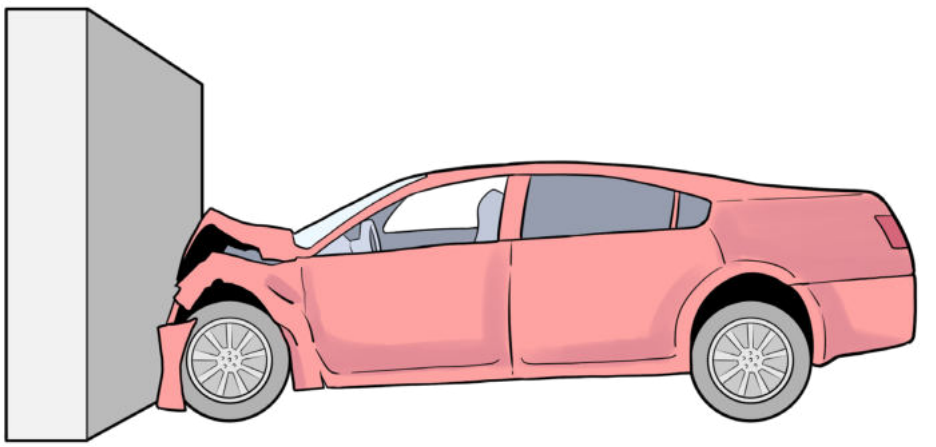
Starting from steady state, $u = 0$

So $v^2 = 2aS$

Or: $aS = \frac{1}{2} v^2$

By substituting the value of aS in the equation $E = maS$, we get, $E = \frac{1}{2} mv^2$

That is, the work W has created a kinetic energy of $\frac{1}{2} mv^2$ inside the object of mass m. You see when work is done, it is not lost rather creates energy!



Vehicle manufacturers regularly check vehicle damage due to kinetic energy.

You have certainly noticed that kinetic energy depends on the square of the velocity. In other words, if the velocity doubles, the kinetic energy quadruples (increases fourfold). For this reason, there is a significantly higher risk of danger when driving at higher speeds.

Example: A person weighing 60 kg is running at a velocity of 3 m/s. What is his/her kinetic energy?

Solution: Here we will at first identify what information is known. The person's mass is 60 kg, which is the value of m. The person is moving with a velocity of 3 m/s which is v, and it has been asked what the kinetic energy, E, will be.
So, we have learnt $E = \frac{1}{2} mv^2$

$E = \frac{1}{2} \times 60 \times 3^2 = 270$ J

That is, the calculation says that the person's kinetic energy is 270 J.
At the very beginning of this chapter, we have learnt about the concept of energy along with the 'conservation of energy'. There are various ways to show the formula of conservation of energy. Let's try to see how this conservation works between the force of gravity and kinetic energy.

In order to discover more fascinating scientific insights, let's once again utilize the third equation of motion in the context of kinetics: $v^2 = u^2 + 2aS$ Assume an object of mass 'm' starting from a stationary position, (i.e. u = 0) and after falling a distance 'h' due to the the force of gravity, the velocity of an object is v. That is, here we can write a=g and s=h. Substituting these values into the equation of motion, we find:

$v^2 = 0^2 + 2gh$

বা, $v^2 = 2gh$

বা, $\frac{1}{2}v^2 = gh$ (Dividing both sides by 2)

বা, $\frac{1}{2}mv^2 = mgh$ (Multiplying both sides by 'm')

Therefore, on the left-hand side, we have got kinetic energy, and on the right-hand side, we have got potential energy. The equation further states that the amount of potential energy consumed is exactly equal to the amount of kinetic energy gained. This is the conservation of energy!

3.4 Relationship between Mass and Energy

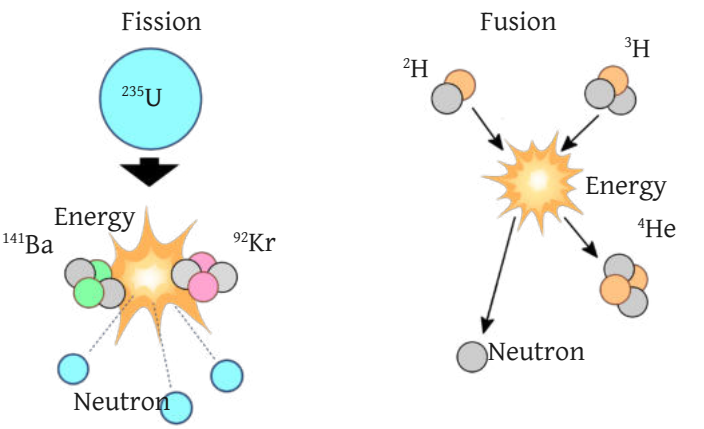
The source of all energy on earth is Sun. It has been radiating light, heat and sometimes energetic ion particles into our solar system for about five billion years, and will continue to radiate energy in this way for another five billion years. If the source of this

energy were chemical reactions, the sun would have run out of fuel long ago. But the source of the sun's energy is nuclear reactions. This is why, we have been getting this huge amount of energy from the sun for so long and will continue to do so in the future.

Burning 1 gram of coal usually produces about 3000 Joules of chemical energy, much of which is lost in various ways. Compared to that, the nuclear energy from 1 gram of matter is 9,00,00,00,00,00,000 joules (13 zeros after nine). That's because nuclear energy comes from Einstein's famous equation E = mc2. Here E is energy, m is mass, and c is the speed of light. In this simple equation, c plays the most significant role because its value is 30,00,00,000 meters/second. And if we square it, it becomes 16) 90,00,00,00,00,00,00,000 zeros after nine) which is not a small number at all. The country's first nuclear power plant at Rooppur will be powered by $E = mc^2$.

It is indeed true when mass is converted into energy, an unimaginable amount of power can be obtained, as expressed by the equation $E = mc^2$. But the process is not very simple or no mass can be easily transformed into energy at your instant wish. The technology behind it is very complex, and so far, it has been possible to extract this power through nuclear reactions involving only a few specific fundamental particles

There are two types of nuclear reactions through which energy can be obtained, namely, fission and fusion. In the fission process, a large nucleus splits into two smaller nuclei, and the mass that is lost in this process is released as energy as $E = mc^2$. This process will be used to create energy in our Ruppur nuclear power plant. In the fusion process, two small nuclei combine to form a larger nucleus, and once again, the mass that is lost is released as energy as $E = mc^2$. Energy is created in this process in the sun. Efforts are being made in various laboratories on Earth to continuously generate energy in controlled environments through fusion reactions. If it is



During fission, a large nucleus breaks up to form smaller nuclei, while in fusion, smaller nuclei join to form a larger nucleus.

successful, it is expected that the world's energy needs will be completely met. We have been discussing the conversion of energy from the beginning. So questions may come to your mind, if mass can be converted into energy, is the reverse true? Can energy be converted into mass? You will be delighted to know that energy can indeed be transformed into mass under special circumstances.

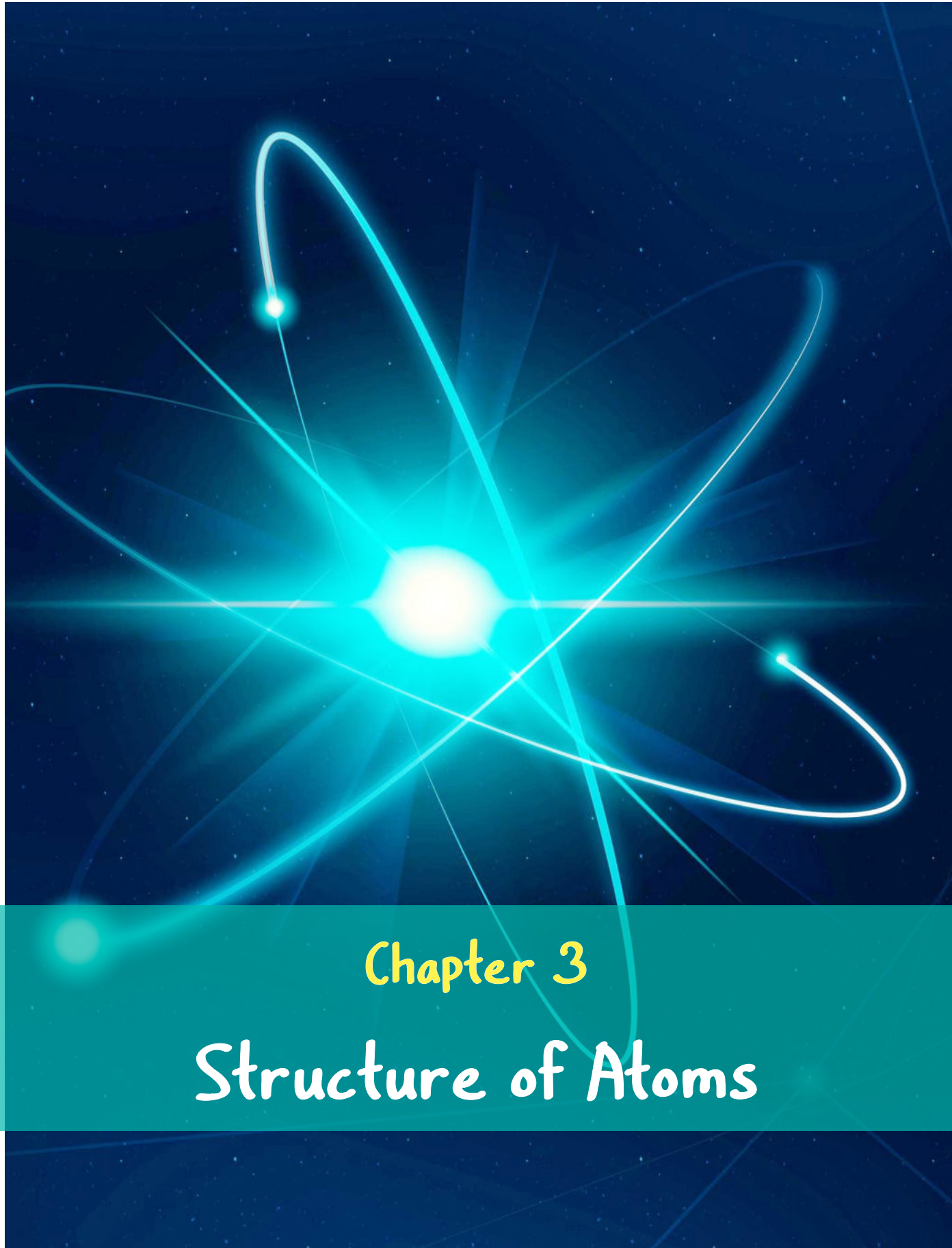
2.5 Power

We see various types of work happening all around us which are performed by humans or machines. It takes different amounts of time for different people (or machines) to do the same work. Some work is done 'fast', while some work is done 'slowly'. Faster work means it takes less time to do the work. Slower work means it takes more time to do the same work. The opposite is also true. By measuring how much work is done in the same amount of time, we can get an idea of the efficiency of the work. In scientific terms, a quantity named power is used to measure the ability to do work. Power can be obtained by dividing the total work by the total time. Since the amount of work is energy, work can also be measured by energy. The amount of energy obtained in a unit of time is called power.

Power = Work/Time Or, Power = Energy/Time

The unit of power is called Watt which is expressed as W. You have definitely seen 15 W or 30 W written on the electric lamp, right? At the beginning of this chapter, we have learnt about the conversion or transformation of different forms of energy. When we write 15 W on a bulb, it means that the bulb consumes 15 J of electrical energy per second and produces 15 J of light energy. Electric bulbs waste some energy as heat in addition to light energy. Tube lights waste less heat energy than filament bulbs, and LED bulbs waste even less heat energy than tube lights.

A 60 watt filament light bulb produces similar amount of light as a -15watt tube light or a -6watt LED light bulb.



Chapter 3

Structure of Atoms

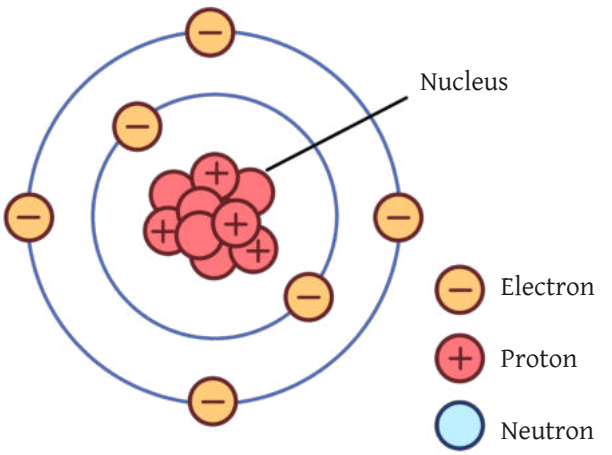
Chapter 3 Structure of Atoms

This chapter deals with the following topics:

- ☑ Structure of atoms, atomic number, mass number
- ☑ Concept of electron in atom
- ☑ How ions are formed
- ☑ Difference between Cation and Anion
- ☑ Determination of chemical formula using cations and anions
- ☑ Concept of isotopes and importance of isotopes in our life

3.1 Structure of atoms

Everything you can see or that is around you but you can't see with the naked eye is made up of tiny particles called atoms. Atoms are so tiny that they cannot be seen with the naked eye, even with the most powerful microscopes we know. Naturally, you might have a question in your mind, how the atom is formed or what it actually contains. The simple answer is that the atom has two main parts: 1) the nucleus at the center of the atom and 2) the electrons revolving around the nucleus outside the nucleus. In the nucleus, there are positively charged protons and neutral neutrons. The electrons orbiting around the nucleus carry a negative charge. When an atom has an equal number of protons and electrons, the total charge is zero, and it is called a neutral atom. The mass of the neutron and proton is approximately two thousand times more than the mass of electrons. Therefore, the mass of an atom is essentially the mass of its nucleus. Atoms can gain or lose a necessary number of electrons to enhance their

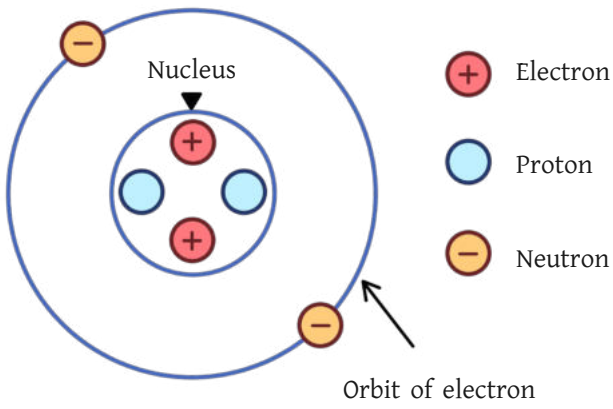


Structure of an atom

stability. Then the atoms are no longer charge neutral and are called ions. Different atoms have different structures because each of them contains a different number of protons and electrons. Basically, for this reason, different elements show different properties.

3.1.1 Origin and advancement of the concept of atoms and atomic model

Now, you all understand that everything is made up of really tiny particles. Scientists and philosophers have given different opinions about these small particles. Back in the 5th century BC, Leucippus and Democritus stated that each substance is made up of a certain number of these tiny particles. According to their view, these particles are indivisible which cannot be divided again. Democritus named these tiny particles atoms. The word 'atom' comes from the Greek word 'atomos,' which means 'indivisible.'



Electron, proton and neutron of a helium atom

Two of their contemporaryy philosophers, Plato and Aristotle, had a different perspective. Aristotle believed that everything is made up of four elements: fire, earth, air, and water and these elements could be divided randomly. However, he did not consider any experiments to prove the ideas. During the 18th and 19th centuries, many scientists attempted to explain the structure of atoms using different atomic models. Those models had certain limitations but they played a crucial role in developing the modern atomic model that we use today. The most notable scientists who contributed to the development of the atomic model are John Dalton, J. J. Thomson, Ernest Rutherford, and Niels Bohr.

Based on experimental proofs, English scientist John Dalton said in 1803 that the atom is the smallest particle of matter and cannot be divided further. However, as we now know, atoms are not indivisible, and neither are the smallest particles of matter. Atoms can indeed be divided. Atoms are composed of very small particles known as electrons, protons, and neutrons.

Other scientists later came up with different models to address the shortcomings of Dalton's model. Among these, the atomic models proposed by Rutherford and

Bohr gained the most acceptance.

Rutherford and his colleagues conducted a significant experiment to determine the exact structure of an atom. From the results of their experiment, Rutherford concluded that all the positive charge and mass of an atom are confined to a small nucleus at its center. He also stated that most of the space inside the atom is empty and the mass of the negatively charged electrons orbiting the positively charged center is negligible. He compared this rotation of electrons to the rotation of the planets around the sun in the solar system. However, Rutherford did not specify any particular orbits for electrons. Later in 1913, scientist Bohr suggested specific orbits for the negatively charged particles. You must have understood from the above discussion that atoms can be broken and if we break an atom, we get electrons, protons and neutrons. At the center of the atom is the nucleus. There are positively charged protons and neutral neutrons inside the nucleus. Most of the mass of an atom is in the center or nucleus of the atom. Since the radius of the nucleus is about a million times smaller than the radius of the atom, all the space between the electrons and the nucleus is empty. In fact, most of the space in an atom is empty.

3.1.2 Atomic number and mass number

You already have some idea about the structure of atoms. It is also important to have some idea about the concepts of atomic number and mass number to gain a better understanding of the structure of atoms.

Atomic number

- The atomic number of an atom is the total number of protons present in its nucleus. It is represented by the English letter Z.
- Different atoms of the same element have the same number of protons, so the atomic number is the same.
- Atoms with different elements have different atomic numbers, which helps to differentiate one element from another element.

For instance, a hydrogen atom has only one proton, so its atomic number is 1. On the other hand, an oxygen atom has 8 protons, giving it the atomic number 8. Since the number of electrons in an atom is equal to the number of protons, we can say that a hydrogen atom has 1 electron and an oxygen atom has 8 electrons. What other information can you get from the atomic number of an atom? For

example, can we know the number of neutrons in an atom from on its atomic number? The answer is no. It is not possible to know the number of neutrons in an atom from its atomic number. To know the number of neutrons, we need to know both the atomic number and the mass number of the atom.

Mass number

☑ The mass number of an atom is the total number of protons and neutrons in that atom. It is represented by the English letter A. For instance, a carbon atom has 6 protons and 6 neutrons, making its mass number 12.

☑ Atoms of the same element may have the same number of protons but different numbers of neutrons. On the other hand,, the mass of an electron is very negligible. Therefore, the atomic mass of an atom is approximately equal to its mass number.

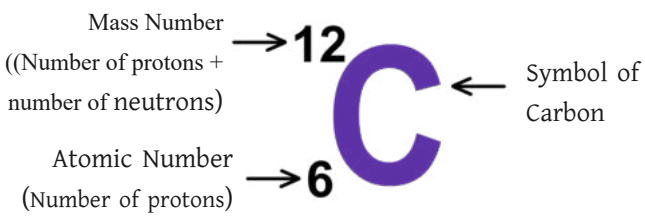
☑ As both protons and neutrons are found inside the nucleus of an atom, they are collectively called nucleons.

As mentioned earlier, if we know the atomic number and mass number of an atom, we can determine the number of neutrons in that atom.

For example, if any atom has the atomic number Z = 9 and the mass number A = 19, then that specific atom has 9 protons and 19 - 9 = 10 neutrons.

3.1.3 (Notation of Atom)

Each atom has a specific symbol, such as H for hydrogen, O for oxygen and C for carbon. To denote an atom, we need to know the symbol, atomic number and mass number of the element. The mass number is written at the top of the symbol and the atomic number at the bottom. For example, the notation of carbon is shown on the side.

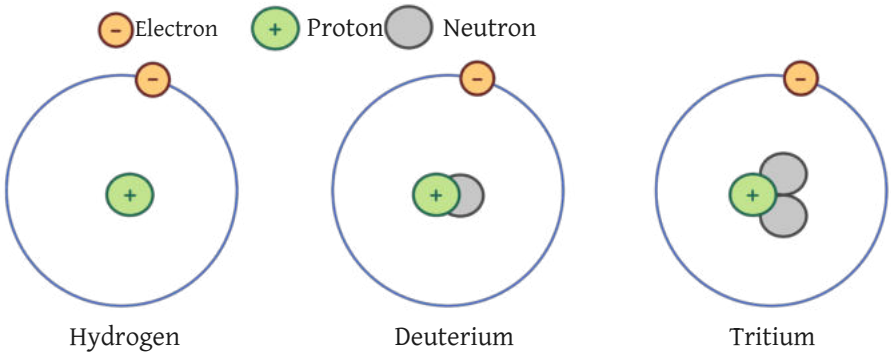


Notation of carbon

3.2 Isotopes

You already know that an atom of an element has a certain number of protons and

electrons. However, as an element can have different number of neutrons, their mass numbers can be different. For example, each hydrogen atom has one electron and one proton. Most hydrogen atoms don't have any neutrons. However, there are some hydrogen atoms that have one neutron, which gives them a mass number of 2. On the other hand, there are also hydrogen atoms that have two neutrons, so their mass number is 3. So, it's possible for a hydrogen atom to have three different atomic numbers. When atoms of an element have the same number of protons and electrons but different mass numbers, they are called isotopes of that element. That's why hydrogen has three isotopes. The diagram below shows the three isotopes of the hydrogen atom. Normally, isotopes of an atom don't have different names, but hydrogen has three different names for its isotopes. Similarly, most carbon atoms have 6 protons and 6 neutrons in their nucleus. But there are some carbon atoms that have 7 or 8 neutrons. So, three different mass numbers of carbon (12, 13 and 14) are possible. Thus, carbon-12, carbon-13 and carbon-14 are the three isotopes of carbon.



Isotopes of hydrogen

3.2.1 Properties and uses of isotopes

Isotopes of an element have the following properties:

(a) Isotopes of a particular element have the same number of electrons and protons, so their electron configuration are the same. Since the electron configuration is responsible for all the electrical and chemical properties of an element, there is no difference in the chemical and electrical properties of different isotopes. However, isotopes can be distinguished from one another because they have different masses.

(b) Isotopes have different physical properties because they have different

numbers of neutrons in their nuclei.

The isotope of an element that is more stable than the others is more commonly found in nature. The stability of an isotope refers to the stability of its nucleus. Unstable isotopes emit different types of light rays and particles through a process called radioactive decay. These special isotopes called radioactive isotopes. These radioactive isotopes are used in a variety of activities. Some uses of isotopes are discussed below.

Medical use

Radioactive isotopes are very useful in the field of medicine for diagnosing and treating different illnesses and diseases. Some of their applications are mentioned below.

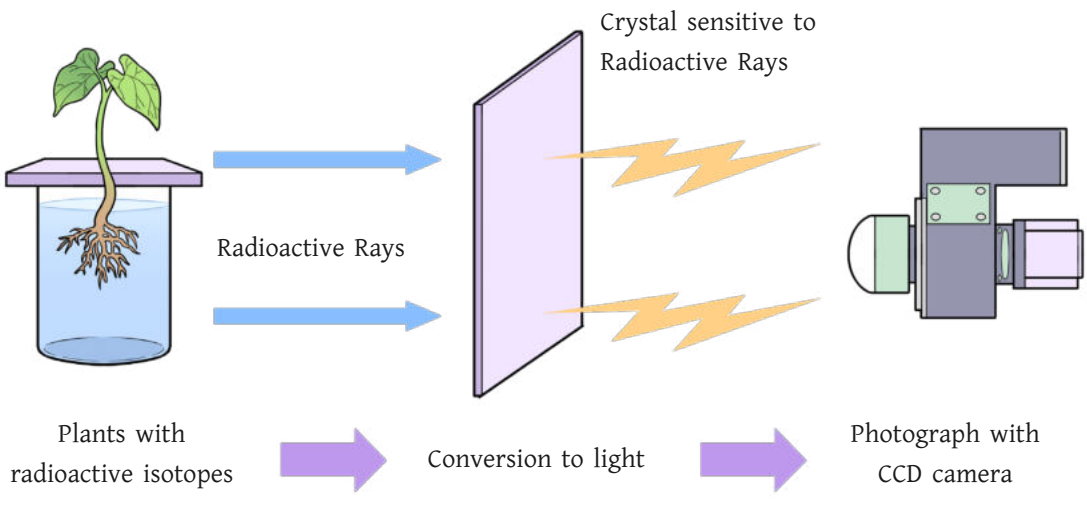
(a) Iodine-131 isotope is used to diagnose diseases of the thyroid gland.

(b) Thyroid function can also be tested using technetium-99 isotope.

(c) If there is a problem in a narrow artery, it can be detected by sending a radioactive isotope through the blood flowing through the artery. Similarly, the location of the affected cells is determined by sending radioactive isotopes into the body of a person with cancer. Radioactive isotopes are also used to destroy cancer cells.

(d) Medical equipment can be sterilized using the irradiation from radioactive materials.

Agricultural use



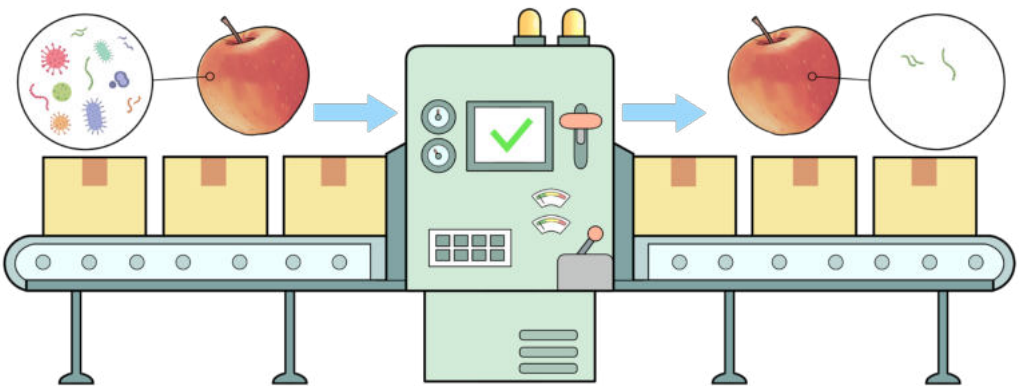
Use of isotopes in agriculture

Some important applications of radioactive isotopes in agriculture are:

(a) Isotope radiation is used to control insects and parasites that can harm crops.

(b) Radioactive isotopes help increase crop yields. They can be used to determine the type and amount of fertilizer required for different crops.

Use of isotopes in food preservation



Use of radioactive rays for bacteria-free food

Radiation from radioactive isotopes can be used to control bacteria and other organisms. As a result, radioactive isotopes can be used to sterilize food and fruit.

Use in geological research

You may have heard news about the discovery of fossils that are several crores of years old. How do scientists know the age of these fossils? Scientists know this studying the decay of isotopes. By examining the ratio of stable and unstable isotopes, the age of the fossil can be calculated.

Use in power generation

Uranium-235 is used as fuel in nuclear reactors to generate electricity in nuclear power plants. When a slow neutron hits the heavy nucleus of Uranium-235, it splits into smaller nuclei, producing a significant amount of thermal energy. This heat energy is then used to generate electricity with the help of generator a generator.

Rooppur Nuclear Power Plant

A new nuclear power plant is being constructed in Rooppur, located in the Iswardi upazila of Pabna district in Bangladesh. This power plant is expected to produce 2,400 megawatts of electricity.

3.2.2 Effects of radioactive isotopes

You have already learned about the various uses of radioactive isotopes. However, these isotopes can be very dangerous to us in uncontrolled conditions. The alpha, beta, and gamma rays emitted by radioactive isotopes can lead to cancer by causing genetic changes in us. During World War II, atomic bombs were dropped on Hiroshima and Nagasaki in Japan, resulting in the immediate deaths of millions of people. Many others suffered long-term complications and eventually dies due to radiation exposure. In 1986, the Chernobyl accident in Russia also caused the loss of numerous lives and extensive damage to the local environment.

3.3 Rules of electron configuration in atoms

The levels of rotation of electrons around the nucleus are called orbits. These orbits extend outward from the nucleus. Each orbit can hold a specific number of electrons. Now the questions are, what is the maximum number of electrons that can be in an orbit? And what are the rules of their configuration?

Rules

1) The maximum number of electrons in an orbit is $2n^2$ (Where, n = 1, 2, 3, 4... is the consecutive number of orbits. The corresponding orbits are also known as K, L, M, N...).

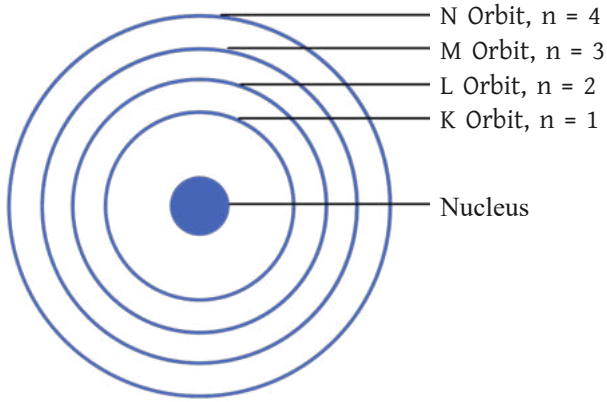
1st orbit: $2n^2 = 2(1)^2 = 2\times1 = 2$; Can have maximum 2 electrons

2nd orbit: $2n^2 = 2(2)^2 = 2\times4 = 8$; Can have maximum 8 electrons

3rd orbit: $2n^2 = 2(3)^2 = 2\times9 = 18$; Can have maximum 18 electrons

2) A new orbit cannot begin until the previous orbit is completely filled.

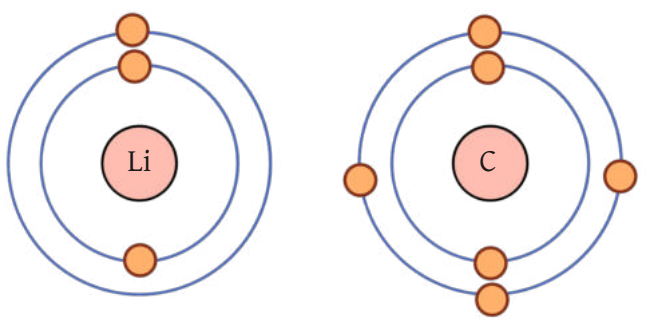
Note that these orbits are called energy levels because each orbit has a specific energy for the electron. You may notice the following example to clearly understand the electron configuration in an atom.



Different orbits within an atom

A lithium atom has 3 electrons. Out of these, two electrons occupy the first orbit, while the third electron is in the second orbit. Similarly, a carbon atom has 6 electrons. 2 of them are in the first orbit and the remaining 4 are in the second orbit.

Now let's look at the electron configuration of sodium atom. Sodium atom has 11 electrons. Can you guess now How many orbits will the electrons of sodium be in? The answer is, the electrons of sodium will be in 3 orbits and its electron configuration can be expressed according to the sequence of orbits as: (2, 8, 1). That is, 2 in the first orbit, 8 in the second orbit and 1 in the third orbit.



Electron configuration of Lithium (Li) and Carbon (C) atoms

The electron configurations of some other elements are shown along with their atomic number and symbol in Table-1 below. See the examples and write the electron configurations of the elements mentioned in Table-2.

Element	Atomic number	Symbol	electron configuration
Hydrogen	2	He	2
Boron	7	N	2, 5
Sulphur	8	O	2, 6
Argon	17	Cl	2 , 8, 7

Element	Atomic number	Symbol	electron configuration
Hydrogen	1	H	
Boron	5	B	
Sulphur	16	S	
Argon	18	Ar	

3.3.1 Electron configuration of elements and their properties

You have already got an idea about the atomic number, symbol, and electron configuration of elements. The properties of elements mainly depend on the configuration of electrons in their atoms. Atoms are of different properties such as active, inactive (inert), metallic, non-metallic, conductive, non-conductive due to the difference in their electron configuration.

For example, if the last orbit contains the maximum number of electrons it can hold, then the orbit is considered to be completely filled. This type of atoms is classified as inactive. For instance, a helium atom has 2 electrons, which occupy the first orbit. Since the first orbit can accommodate a maximum of 2 electrons, the helium atom is inactive. Similarly, in the case of neon (Ne-10) gas, 8 electrons in the last orbit have completely filled its second orbit, so this gas is also inactive.

3.4 Formation of ions

Sometimes an atom with one or more atoms more or less in its last orbit can become fully or partially filled and stable similar to the nearest inert gas. These atoms lose or accept one or more electrons from the outermost energy level to achieve a stable electron configuration similar to their nearest inert gas. When atoms lose negatively charged electrons, they become positively charged and are no longer neutral. When atoms gain electrons, they become negatively or positively charged. These charged atoms are known as ions.

When an atom loses one or more electrons from its outermost energy level and gains a stable electron configuration similar to that of the nearest inert gas, it transforms into a positively charged ion. This type of ion is called a cation. Let's consider the sodium atom as an example. Sodium has 2 electrons in its first energy level, 8 electrons and 1 electron in its second and third energy levels respectively. If the sodium atom loses one

electron in its third energy level, the second energy level becomes the new outermost energy level, and it becomes filled with 8 electrons. In this way, sodium gains a stable electron configuration similar to its nearby inert gas, neon. When a second atom capable of accepting an electron comes close to sodium, sodium easily loses an electron from its third energy level.

When the outermost energy level of an atom gains one or more electrons and attains a stable electron configuration like the nearest inert gas, it transforms into a negatively charged ion. This type of ion is known as an anion. Now let's look at an example of the formation of an anion. The electron configuration of a chlorine atom, with an atomic number of 17 is: 2, 8, 7. Is chlorine stable? Undoubtedly not. It requires 8 electrons in its outer shell to gain stability. In order to attain 8 electrons in the third energy level, chlorine can either release 7 electrons from its outermost level or gain an additional electron from elsewhere. In terms of energy, it is much easier for chlorine to gain an electron in its third energy level rather than giving up 7 electrons. It can easily accept an electron from a sodium in contact with a sodium atom. After accepting the electron, the chlorine atom transforms into a negatively charged ion called an anion.

This is how atoms transform into ions by gaining or losing electrons. Chemical bonds are established through the attractive forces between cations and anions with opposite charges. This is how compounds are formed from the atoms of two different elements. You will learn more about this in your next class. Below is an example of how sodium chloride is formed. As you see, in the first step, sodium gives up an electron to become a sodium ion with a positive charge, which is represented as Na+. Similarly, in the next step, chlorine gains an electron, to become a negatively charged chlorine ion. Hence, it is represented as CI-.

$$\begin{aligned} Na &\longrightarrow Na^{+} + e^{-} \\ F + e^{-} &\longrightarrow F^{-} \\ \hline Na + F &\longrightarrow Na^{+}F^{-} \text{ or } NaF \end{aligned}$$

Sodium fluoride is a useful compound. It is used in water and toothpaste to prevent tooth decay.

3.4.1 Rules for writing chemical formulas of compounds with the help of cations and anions:

If you know the name of an ionic compound, you can also write its chemical formula.

First, the elements in the compound are to be separated into anions and cations. For that you need to know how many electrons can be given up to become a cation or how many electrons can be gained to be an anion to make a full orbit nearby. Then, write the two ions along with their charges. Since the entire compound is charge neutral, the quantity of ions taken determines how much they will neutralize each other's charges. Two examples are shown below.

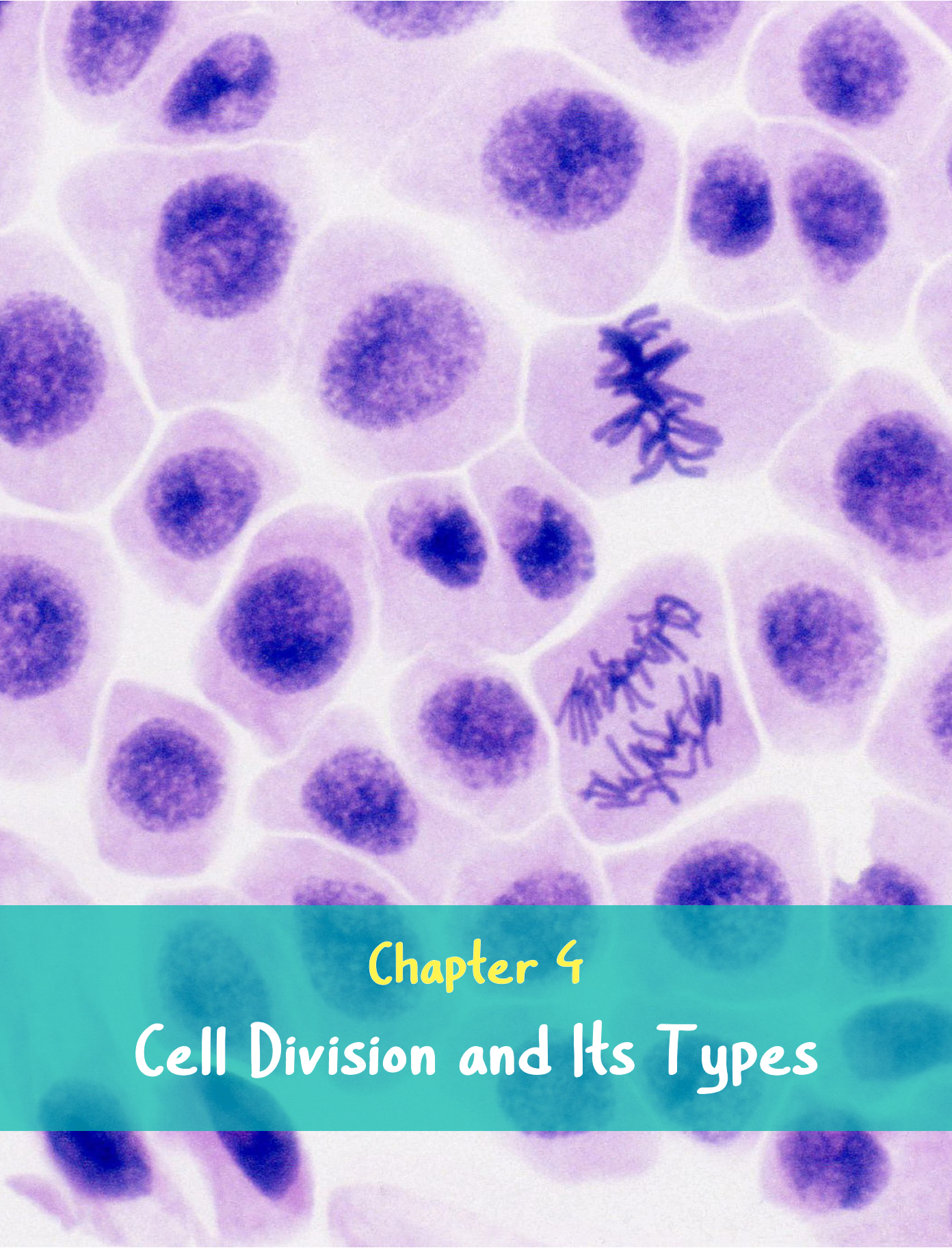
Lithium Oxide:

Lithium (Li-3) and oxygen (O-8) combine to form lithium oxide compounds. Lithium can fill the last n = 1 energy level by giving up an electron. So, its cation is Li^{+}. On the other hand, oxygen can gain two electrons and fill its last n = 2 energy level. So, its anion is O^{2-}. Therefore, two lithium atoms and one oxygen atom combine to form the charge neutral lithium oxide Li_2O compound.

Magnesium oxide:

Magnesium (Mg-12) and oxygen (O-8) combine to form lithium oxide compounds. Magnesium can fill the last n = 2 energy level by giving up two electrons. So, its cation is Mg^{2+}. On the other hand, oxygen can gain two electrons and fill its last n = 2 energy level. So, its anion is O^{2-}

Therefore, one magnesium atom and one oxygen atom combine to form the charge neutral lithium oxide (MgO) compound.



Chapter 4

Cell Division and Its Types

Chapter 4 Cell Division and Its Types

This chapter deals with the following topics:

- ☑ Cell division and genetics:
- ☑ What is cell division and its types
- ☑ Mitosis and meiosis cell division and cell cycle
- ☑ Phases of mitosis cell division and their control
- ☑ Importance of mitosis cell division
- ☑ Phases of meiosis cell division and their control
- ☑ Importance of meiosis cell division
- ☑ Abnormal cell division and its consequences
- ☑ Cell division and irreversible flow of DNA
- ☑ Roles of DNA in determining genetics

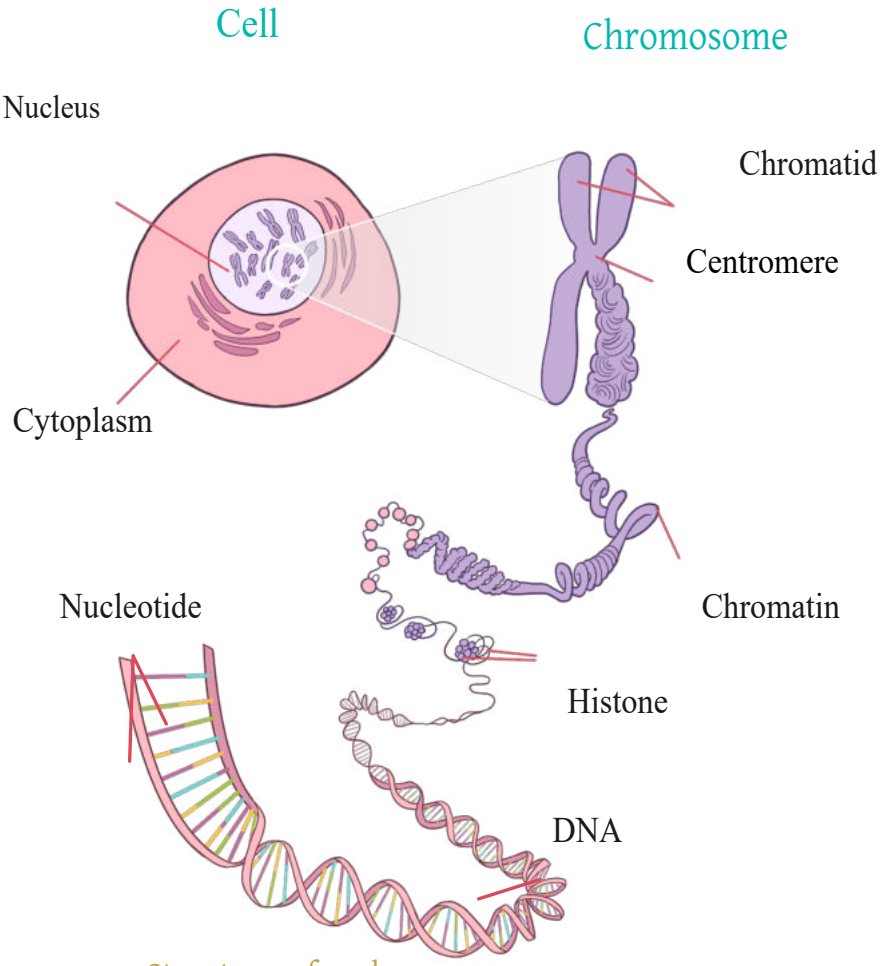
Cells are the structural unit of the body of all living beings. The body of living beings can be either unicellular, like bacteria, amoeba, or plasmodium, or multicellular, like humans, banyan trees, and whales. The body of all living beings except unicellular organisms are made up of numerous cells. Every living being reproduces and multiplies cells through cell division. The physiological process in which one cell produces more cells is called cell division. Cell division is a normal and important process. Through cell division, a single cell can divide and transform to a complete organism by producing numerous cells. The process by which the unicellular eukaryotes usually divide is called amitosis. Multicellular organisms divide in two processes: mitosis and meiosis.

Importance of cell division:

Cell division is essential for the physical growth, reproduction, and maturity of living organisms. All cells are created through the process of division from their parent cells. Cell division also plays a crucial role in healing the body when it gets hurt or damaged. Again, cell division in gametes is one of the means for the reproduction of living organisms. Through this process, daughter (newborn) cells with new characteristics are formed, which also play an important role in the adaptation, appearance and continuation of the living organism.

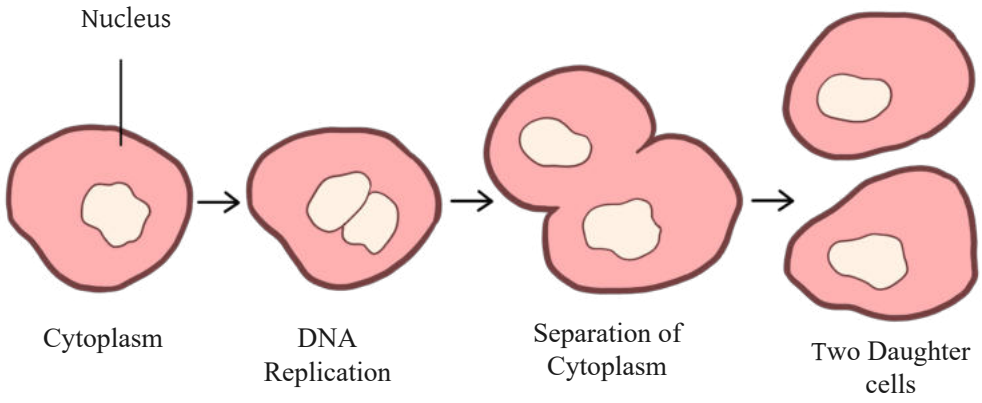
Structure of a cell:

In class seven, you learned about the structure of plant and animal cells. Then, you saw that the two main components of a cell protected by a cell membrane are cytoplasm and nucleus. The dense opaque organelle in the centre of the cell is the nucleus while the rest outside the nucleus and wrapped by the cell membrane is the cytoplasm. The nucleus is enclosed by the nuclear membrane. Inside the nucleus, there are chromosomes made up of DNA, the genetic material of the organism. Normally, a long chromosome is coiled on protein particles called histones and remains as an open lattice called chromatin. That's why, it cannot be understood individually. It is only visible during cell division when it coils up and contracts.



Structure of a chromosome

4.1 Cell Division in Unicellular Organisms: Amitosis



Amitosis cell division

Unicellular eukaryotes reproduce through a direct division process called amitosis or binary fission. This type of cell division occurs in eukaryotic organisms such as bacteria or blue-green algae. This process is highly efficient for the rapid proliferation of single-celled organisms as it does not require any special preparation of the cells for division and it allows for a quick increase in the number of cells. In amitosis cell division, the DNA of the chromosome is replicated inside the nucleus when the cell matures. The cell nucleus undergoes changes and transforms into a dumbbell shape and starts to shrink around the middle. At the end of contraction, the original elongated nucleus of the mother cell separates into two daughter nuclei. There is no guarantee that the DNA in the two nuclei will be divided precisely and equally in this process, so the two nuclei may be different. Along with the nucleus, the cytoplasm also shrinks in the middle and divides into two cells. In this type of division, both the nucleus and the cytoplasm of the mother cell divide directly to create two daughter cells. That's why, it is called direct cell division.

4.2 Cell Division in Multicellular Organisms

We are multicellular organisms. Our body contains around one trillion cells. There are different types of cells in our body, such as: blood cells, muscle cells, skin cells, stomach cells, etc. Each of the different types of cells has its own structure and function. All these cells come from a special type of cell called stem cell. All

animals and plants require stem cells. An animal that is not fully developed is called an embryo. Stem cells in the embryo can develop into different types of cells.

All stem cells have certain characteristics: Stem cells divide and produce more stem cells. Stem cells also have the ability to develop into different types of cells. A stem cell divides into two new cells; each new cell is identical to the original cell. When mature, these cells also divide. This ensures the supply of stem cells to the embryo. A growing embryo and its organs need lots of stem cells to flourish. In the laboratory, starting with a few stem cells, scientists have been able to create millions of cells within months. Scientists are researching the problem of how stem cells change into other types of cells.

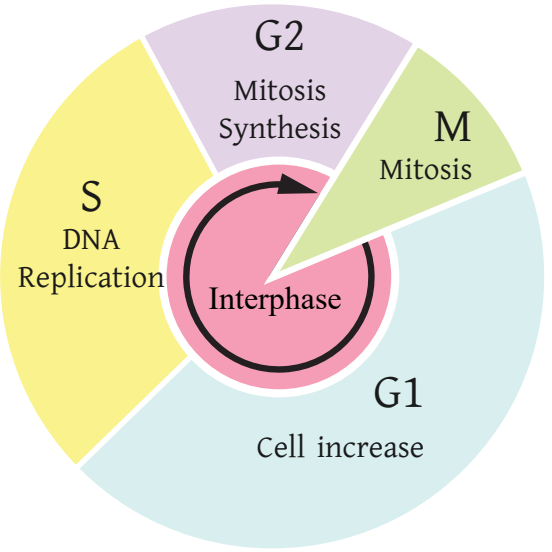
Now, we will learn about cell division in multicellular organisms.

The process by which the cells of multicellular organisms divide is called mitosis. Again, meiosis cell division occurs in the reproductive mother cells of sexually reproducing organisms. Mitosis occurs in the tissues of the growing regions of the plant body such as root and tip of the stem, embryo bud, embryo root and leaf. Again, in the anthers and ovules of angiosperm (flowering) plants, cells divide in the meiosis process.

Cell Cycle

The cell that initiates the process of cell division is known as the mother cell, and the newly formed cell is called the daughter cell. The cycle through which a mother cell is formed, grows and divides into two daughter cells is called a cell cycle. The cell cycle is divided into two main phases: the dividing stage known as the mitosis phase (M phase) and the intermediate non-dividing stage is called interphase. Approximately 90-95% of the cell cycle is spent in the interphase stage and the remaining 5-10% is spent in the mitosis stage or M phase. The interphase stage can be further divided into three phases: G1 (30-40% of the time), S (30-50% of the time), and G2 (10-20% of the time). G1 (Gap 1) is the first phase after one cell division that prepares for the next cell division cycle. During this phase, the cell increases in size and monitors its surroundings to determine whether it should proceed with division. The next S (Synthesis) phase is replication stage in which the DNA is replicated to create an exact copy of each chromosome. In the subsequent G2 (Gap 2) phase, any errors in DNA replication are corrected. This phase occurs before the start of the mitosis process. In this phase, each chromosome has its exact replica attached to the centromere and are called chromatids. After the end of G2 phase, mitosis begins, as described below.

It is important to know how this cell cycle is controlled, because if the cell cycle occurs without any control, cells can move from one phase to the next before they are ready. It is very harmful to cells. Disruption of the normal control of the cell cycle can lead to serious diseases such as cancer. Naturally, you may wonder how the cell cycle is controlled, that is, how the cell knows when to grow, when to replicate its DNA, or when to divide. The cell cycle is mainly controlled by some regulatory proteins. These proteins ensure that the previous phase is completed before the cell can move on. These proteins also control the cycle by signalling the cell to start or delay the next phase of the cycle.



Cell Cycle

4.2.1 Mitosis

The process of creating two daughter cells from a mother cell to build a multicellular organism is called mitosis. In this process, the cytoplasm, nucleus and chromosomes are equally divided in both the cells and the cells have the same number and quality of chromosomes as the mother cell. That is, mitosis enables a somatic cell to divide and generate two daughter cells that are identical to the original mother cell. This type of division happens in the body cells of organisms that have a true nucleus. As a result of this division, animals and plants increase in length and width by increasing the number of cells.

You have already learned that mitosis does not occur in unicellular prokaryotic organisms. Also, mitosis does not occur in the mother cells of multicellular organisms, animal nerve cells, matured red blood cells and platelet of mammals and in the cells of permanent tissues of plants.

Phases of Mitosis Cell Division

Mitosis cell division is a continuous process. This division is usually completed in two stages.

While reading about the cell cycle, you have learned that each chromosome in the cell is made one replica at a time in interphase in preparation for the process of mitosis. The steps in the process of mitosis are:

(a) Prophase: The first stage of mitosis is prophase. In this stage, the nucleus of the cell gets bigger. At the start of prophase, the replica of the cell along with its each chromosome in the cell is connected to the centromere and they are called chromatids. At this stage, the fibrous spindle apparatus begins to form at the two poles of the nucleus. Meanwhile, inside the nucleus, the chromatids coil up tightly like springs, getting shorter and fatter. During this stage, the nucleolus and nuclear membrane inside the nucleus continue to disappear.

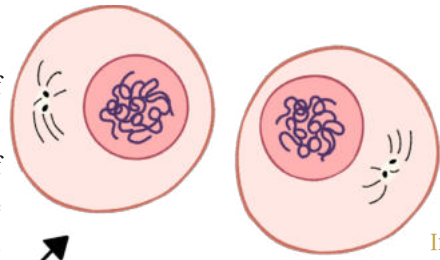
(b) Metaphase: At this stage, the chromosomes are arranged in the middle point (in the equatorial region) of the bipolar fibre-enriched spindle apparatus built inside the nucleus. The centromere of each chromosome is located at the equatorial region, while chromatids arms are positioned towards the poles. The chromosomes appear the shortest and fattest at this stage. Towards the end of this stage, the centromere splits into two, forming two daughter centromeres, and the nuclear membrane completely disappears.

(c) Anaphase: At this stage of cell division, because of the division of the centromere of each chromosome, the two chromatids become separate. These two chromatids are called daughter chromosomes and each one has a centromere attached to it. The daughter chromosomes start moving from the intermediate or equatorial region towards opposite poles. As they move towards poles, the centromeres of the daughter chromosomes lead the way and the chromatid arms follow them behind. During this stage, the spindle fibres almost disappear. This phase ends when the daughter chromosomes reach the poles of the cell.

(d) Telophase: Telophase is the final stage of mitosis cell division. In this stage, the daughter chromosomes reach the opposite poles. The chromosomes start to become narrower and longer again. The nucleolus and nuclear membrane reappear, creating two daughter nuclei at the two poles. The structure of the spindle apparatus starts to disappear and eventually disappears completely.

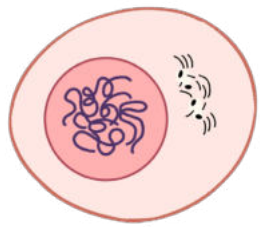
(e) Cytokinesis: The process by which the cytoplasm of a dividing cell splits into two is called cytokinesis. At this stage, along with the division of the nucleus, two grooves are formed on either side of the nuclear membrane in the middle part of the

Differnt Steps of Mitosis



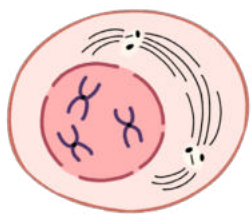
Interphase

Each chromosome in the cell is made one replica at a time in preparation for the process of mitosis.



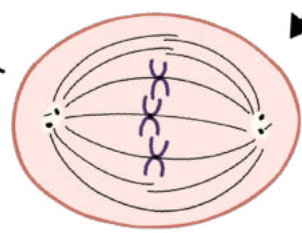
Prophase

The chromatids coil up tightly like springs, getting shorter and fatter.



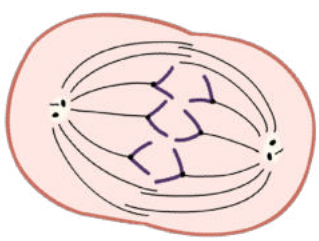
Metaphase

The centromere splits into two, forming two daughter centromeres, and the nuclear membrane completely disappears.



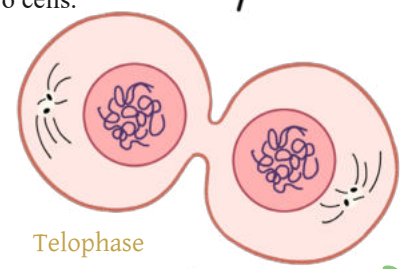
Anaphase

The daughter chromosomes start moving from the intermediate or equatorial region towards opposite poles.



Telophase

The daughter chromosomes reach the opposite poles and start to become narrower and longer again.



Cytokinesis

Along with the division of the nucleus, two grooves are formed on either side of the nuclear membrane in the middle part of the cell. This groove gradually deepens and unite and ultimately divides into two cells.

cell. This groove gradually deepens and unite and ultimately divides into two cells. The equal distribution of the cytoplasmic organelles leads to the creation of two complete daughter cells.

Importance of Mitosis Cell Division

Mitosis cell division is very important for the growth and stability of the cell population. The significant importance of mitosis cell division is given below:

1. In multicellular organisms, physical growth is accomplished through mitosis cell division from only one cell called a zygote.

2. The normal size, shape, volume and quality of the mother cell is maintained in the daughter cell through mitosis cell division.

3. Mitosis cell division ensures a balance between the nucleus and cytoplasm of cells.

4. All cells in the body have the same number and type of chromosomes because of the process of mitosis cell division.

5. Mitosis cell division helps to fill in any gaps that occur in a multicellular organism.

6. Certain very important cells have a limited lifespan and are constantly depleted. They reproduce in the process of mitosis cell division.

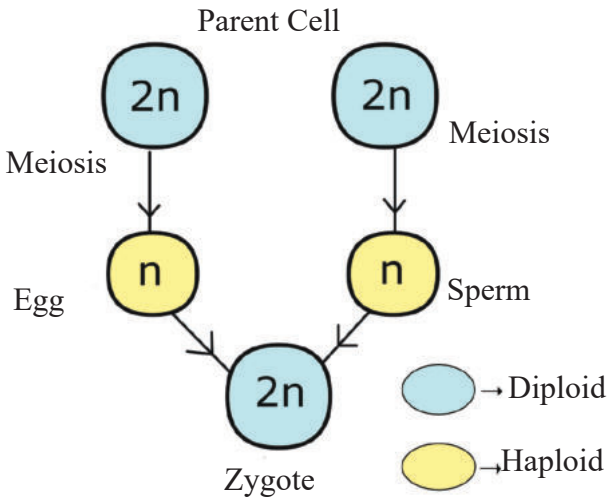
Control of Mitosis Cell Division

In mitosis cell division, the number of cells increases from one to two, and then from two to four. Mitosis cell division process is regulated by various internal and external factors of the organism. When cell division becomes uncontrolled due to the presence or absence of certain factors in different physiological conditions, it can lead to the development of tumours, which can later turn into cancer. Research has shown that pathogens, chemicals, or radioactivity can act as external influencers in uncontrolled mitosis cell division. Cancer can potentially affect almost all organs in the body, such as the liver, lungs, brain, breasts, skin, and colon.

4.2.2 Meiosis

When a cell has two sets of chromosomes, it is called diploid. Humans are diploid because each human cell has a total of 23 pairs of chromosomes. Out of these 23 pairs,

23 chromosomes come from the father's sperm cells and the other 23 chromosomes come from the mother's egg cells. You can understand that sperm cells and egg cells are different from other human cells. They have only 23 chromosomes instead of 23 pairs, and they are called haploid. When we talked about mitosis, we saw that daughter cells are exactly like the mother cells. So, we can never get diploid to haploid by mitosis cell division and for that we need a different type of cell division called meiosis.



Creation of Zygote

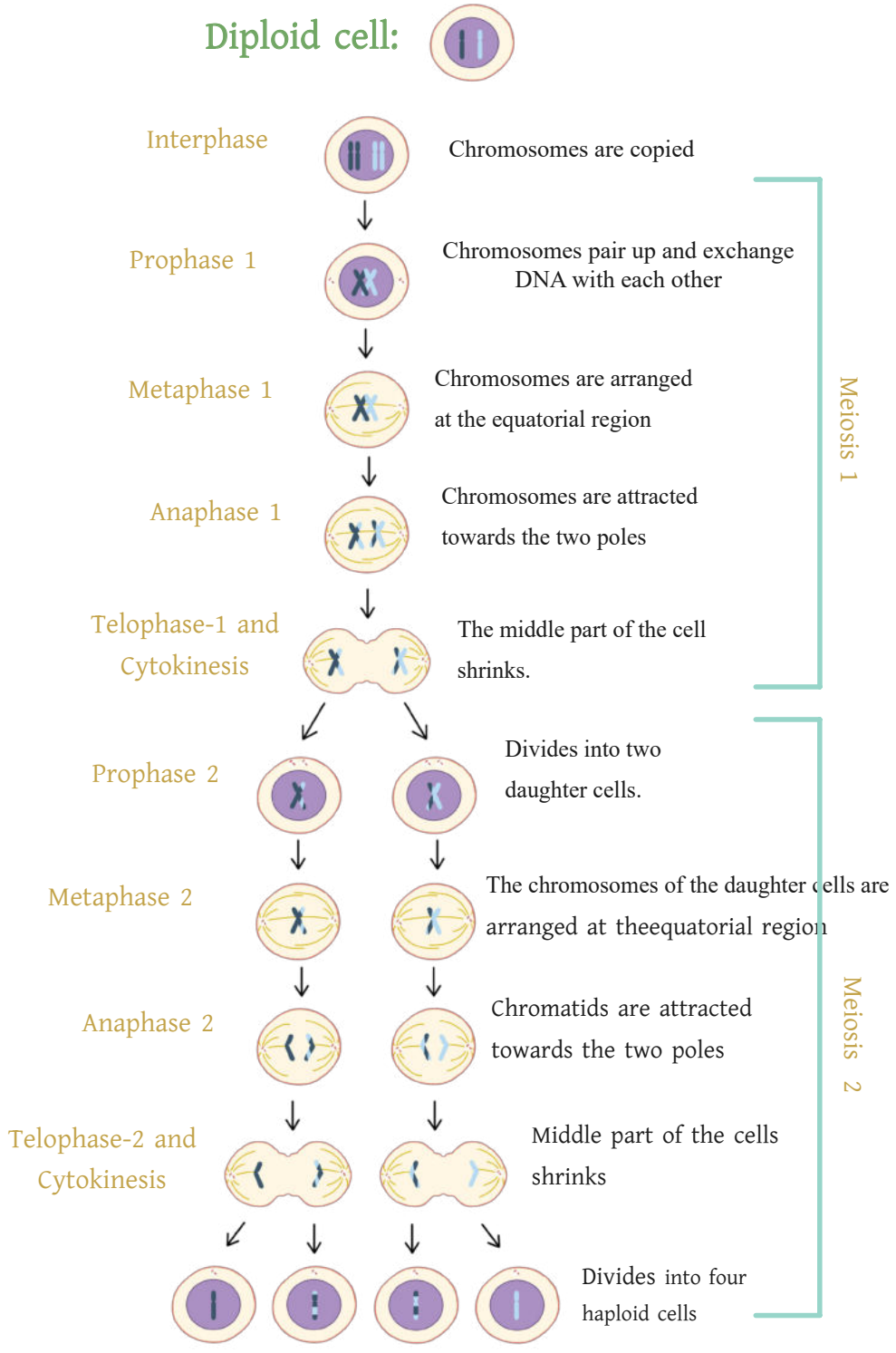
Before undergoing cell division in the process of meiosis, a diploid mother cell goes through the interphase stage, which is similar to mitosis. Similarly, during the S or replication phase of the cycle, each of the chromosomes replicates itself.

Phases of Meiosis Cell Division

The process of meiosis cell division can be divided into two main stages: Meiosis1- and Meiosis2-. In the first stage, Meiosis1-, two cells are formed, each containing one chromosome from each pair of chromosomes. The second division is similar to mitosis division. That is, each cell produced in the first division divides again in two and produce a total of four daughter cells. Meiosis1- phase can be divided into four main phases: Prophase1-, Metaphase1-, Anaphase1- And Telophase1-. Similarly, Meiosis2- stage can be divided into four stages: Prophase2-, Metaphase2-, Anaphase2- And Telophase2-.

The figure shows the transition of a diploid cell containing the same pair of chromosomes to different stages of Meiosis 1- And Meiosis 2-. In case of humans, it would start with 23 pairs of chromosomes instead of one pair. During the interphase stage of the cell cycle, before the meiosis process begins, each of the two identical chromosomes of a diploid cell produce one more replica.

☑ Prophase1-: Chromosomes pair up and exchange DNA with each other



The process of meiosis cell division

(crossing over).

☑ Metaphase1-: Chromosomes are arranged at the equatorial region.

☑ Anaphase1-: Chromosomes are attracted towards the two poles.

☑ Telophase1- and Cytokinesis: The middle part of the cell shrinks.

☑ Prophase2-: Divides into two daughter cells.

☑ Metaphase2-: The chromosomes of the daughter cells are arranged at the equatorial region.

☑ Anaphase2-: Chromatids are attracted towards the two poles.

☑ Telophase2- and Cytokinesis: Middle part of the cells shrinks and divides into four haploid cells.

Importance of Meiosis Cell Division

Meiosis cell division has an immense importance in the organism world. A few key points are mentioned below:

1. Meiosis results in the formation of gametes or reproductive cells in diploid organisms. As reproduction occurs through the union of reproductive cells in the sexual process. That's why, reproduction is not possible in organisms without meiosis cell division.

2. In order to maintain the uniqueness of the species in heredity, chromosome number must be accurate. The chromosome number remains unchanged in meiosis cell division.

3. The crossing over of gametes in meiosis cell division has resulted in diversity in the biosphere (living world).

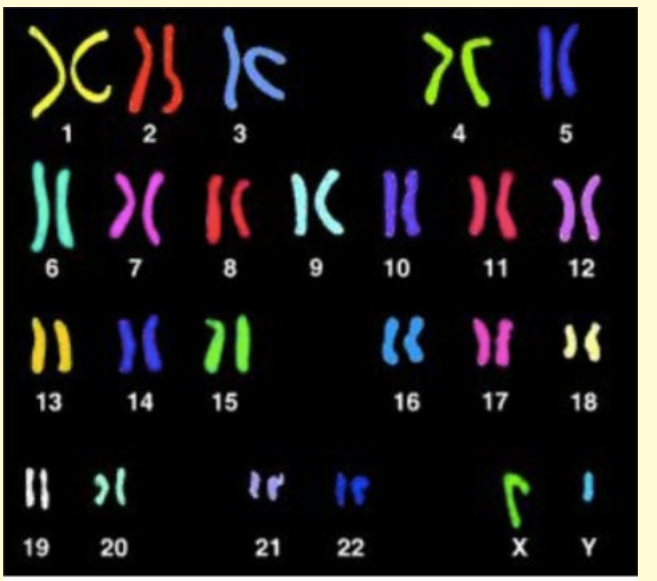
4.3 Roles of Chromosomes and DNA in Determining Genetics

What physical traits do you possess? Some of you have curly hair, while others have straight hair. Some might have long hair, while others have short hair. Some may have black hair, while others have brown eyes. These different characteristics in your bodies are determined by the DNA (deoxyribonucleic acid) present in the chromosomes of your cells. All the information that determines the

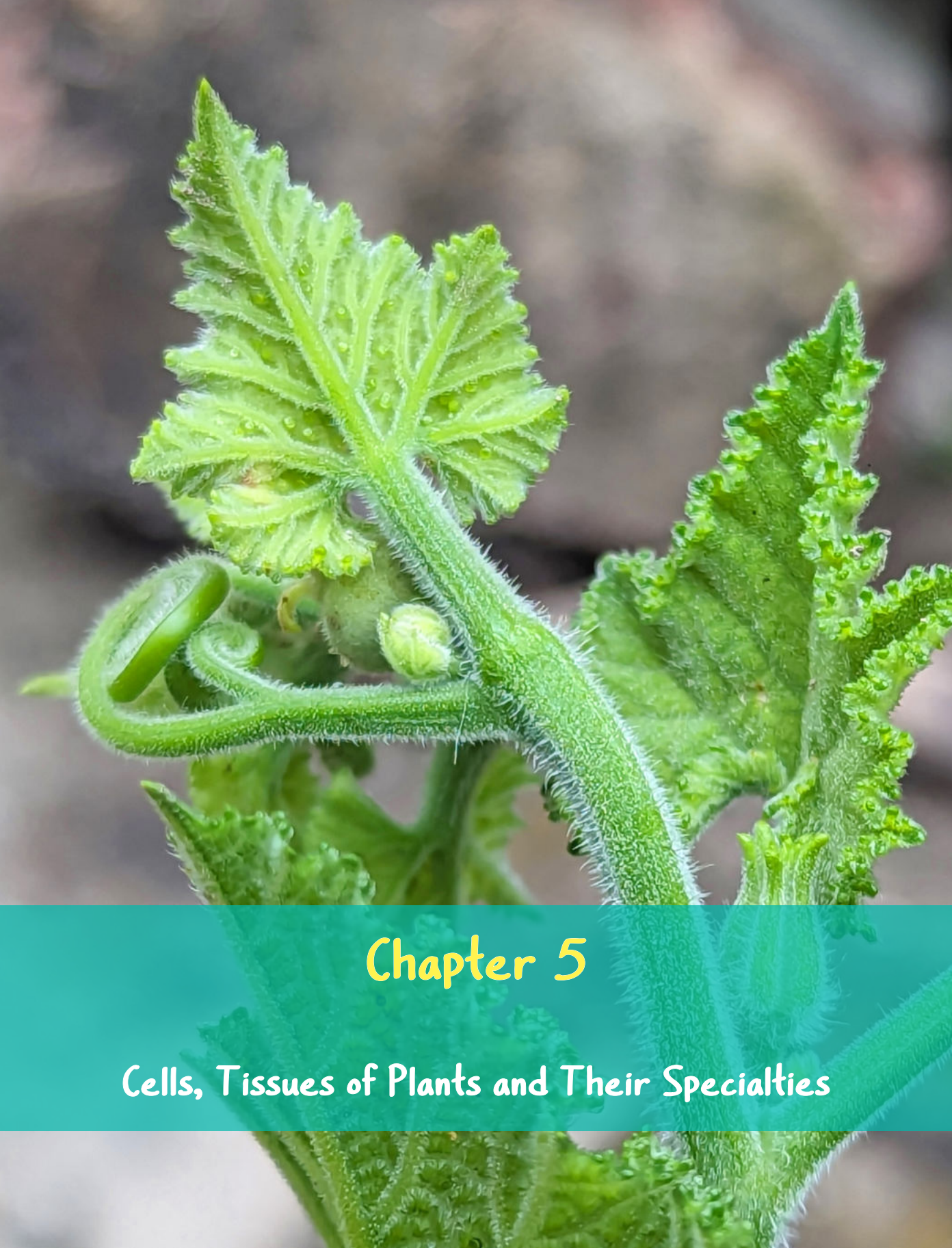
characteristics of an organism is stored in DNA. DNA carries traits directly from parents to their offspring, and this process is known as genetics. DNA plays a crucial role in controlling the characteristics of chromosomes and in maintaining the linage of genetics. Only DNA acts as the agent of genetics and keeps continue the chain of genetics. During meiosis cell division, the DNA located on the chromosomes is directly carried from the parents to the next descendants. This is why, chromosomes are referred to as the physical basis of genetics. You will know more details about this topic in higher classes.

Male and female child

The first 22 chromosomes in male and female reproductive cells are the same. However, the 23rd chromosome can be different for male and female reproductive cells. In female egg cells, the 23rd chromosome is always X, while in male sperm cells, it can be either X or Y. When the male and female cells unite, the 23rd pair of chromosomes can be either XX or XY, depending on whether the male contributes an X or Y chromosome. If the 23rd pair of chromosomes is XX, the child is female, while if it is XY, the child is male. If you look at the attached images of chromosomes, you will see that the X and Y chromosomes are different in size. The Y chromosome is much smaller than the X chromosome.



Humans have 23 pairs of chromosomes.



Chapter 5

Cells, Tissues of Plants and Their Specialties

Chapter 5 Cells, Tissues of Plants and Their Specialties

Plant Physiology :

- ☑ Cells, tissues of plants and their specialties
- ☑ Organs of plants and their functions
- ☑ Diffusion, transpiration and transportation in plants
- ☑ Plant tissue culture and its use

You have already known that cells are the structural units of the living organisms. The body of lower-level plants is composed of one cell. All physiological functions of the plants in this class are carried out by this single cell. However, higher-level plants have more complex structures and functions. Higher-level plants function in combination of various organs. Different organs also have different functions, such as one organ might transport water and minerals, another provides rigidity, and another helps the plant grow. Cells can also vary in size depending on their specific function. Since one cell alone can't perform all the functions, many cells collaborate to carry out the necessary physiological functions. When a bunch of plant cells collectively perform essential physiological functions, they are called tissues

5.1 Tissue and Its Types

You might have noticed that plants germinated from seeds grow up slowly. During this time, as more leaves appear, the stem also gets bigger and stronger, and roots start to form. Which type of tissue performs these functions? Are they the same or different? We will now discuss these issues a bit.

Plants grow because of cell division. So, based on how the cells in the tissue divide, all types of tissue can be divided into two categories: Meristematic Tissue and Permanent Tissue. These two types of tissue have some differences, which are as follows:

5.1.1 Meristematic Tissue

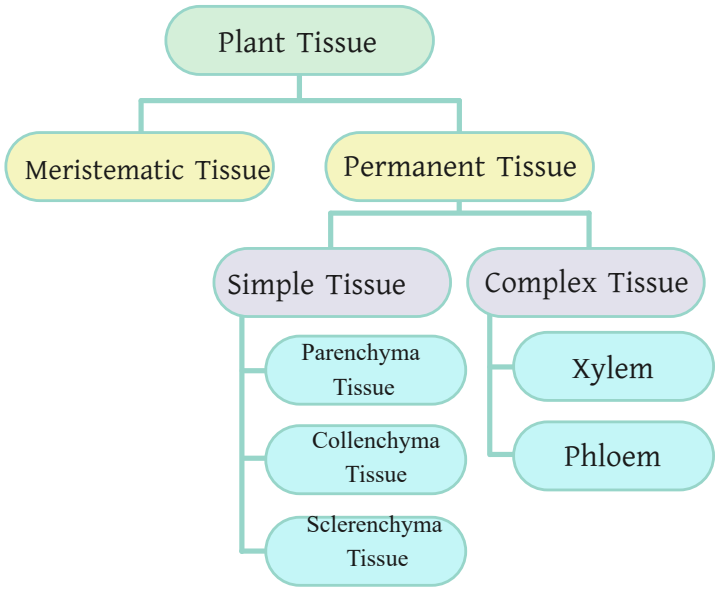
Organisms grow because of continuous cell divisions in certain groups of cells. The cells that have the ability to divide are called meristematic cells and tissues made up of

meristematic cells are called Meristematic Tissues.

Characteristics:

Some of salient features of the Meristematic Tissue are given below:

1. The cells are alive and relatively small.
2. The cells of the meristematic tissue are usually rectangular, oval, pentagonal or hexagonal.
3. The cells in the meristematic tissue have thin cell walls made of cellulose.
4. The nucleus of the cell is relatively big, and the cytoplasm is dense.



Types of Tissue

5. The cells of the meristematic tissue usually do not have vacuoles.
6. As the cells are densely packed, there are no intercellular spaces between them.
7. Cells do not have stored food, secretions or waste products.

Functions:

1. Plants grow in length and width through division of the meristematic tissue.
2. Permanent tissue is formed from the meristematic tissue.
3. The wounds get filled through division of the meristematic tissue.

5.1.2 Permanent Tissue

When the meristematic tissue of a plant is completely formed and stays permanently in a certain place of the plant and does not divide again, it is called permanent tissue. The cells of this tissue are fully developed and have the right shape and size.

Characteristics:

Some of characteristics of the Permanent Tissue are given below:

1. The walls of the cell are chubby and quite thick.
2. The vacuoles are relatively big.
3. The nucleus is smaller than usual and positioned to one side of the cell.

4. The cell wall displays different patterns or designs.

Functions:

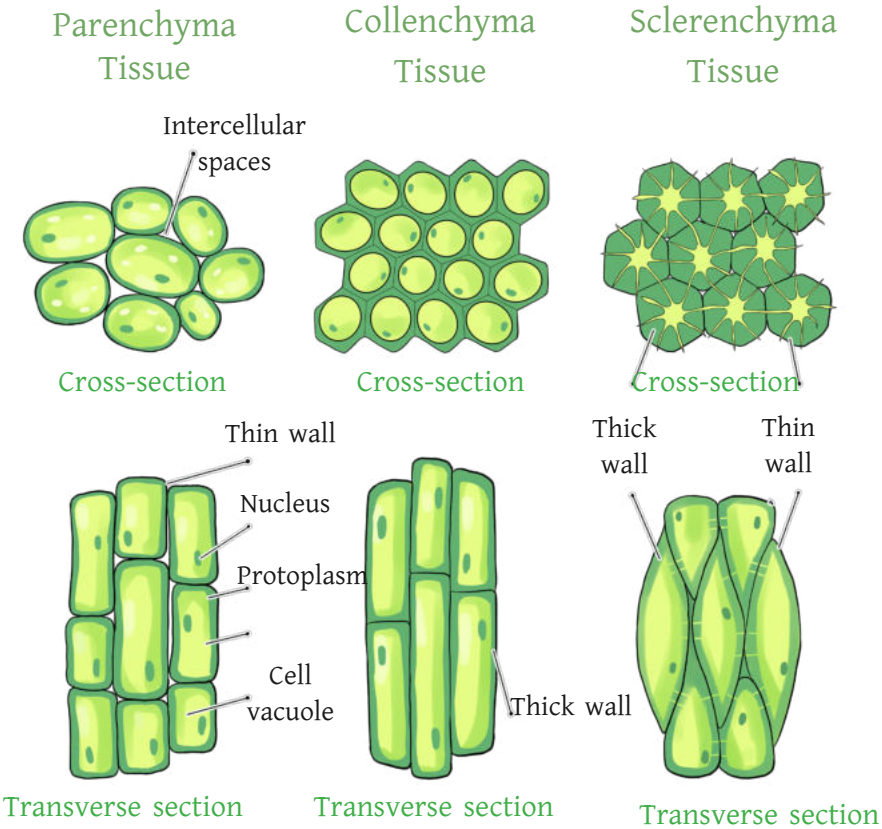
The main function of the permanent tissue is to participate in conduction and convection. Permanent tissues can be divided into two types: Simple and Complex.

Simple Tissue

Each cell in some permanent tissues has the same size, structure and shape. These tissues are called simple tissues. There are three types of simple tissues. They are:

(a) Parenchyma Tissue:

These tissues are present in all parts of the plant. The cells of this are alive, have thin walls, and are filled with protoplasm. These tissues have intercellular spaces. The cell walls are thin and made of cellulose. The main functions of parenchyma tissue are providing structure to the body, preparing and storing food, and transporting food.



Three types of simple tissues

(b) Collenchyma Tissue:

These tissues are composed of a special type of parenchyma cells. The cells of this tissue are alive, filled with protoplasm, and have a lengthened shape. The cell

walls of collenchyma tissues are thick because they contain carbohydrates named cellulose and pectin. This tissue gives the plant body strength and elasticity, for which the stems of plant can bend instead of breaking down.

(c) Sclerenchyma Tissue:

The cells in this tissue are tough, long, and have thick walls. Sclerenchyma tissues do not contain protoplasm. Although protoplasm is initially present in the cells, they soon decay and become dead cells. This tissue contains a type of organic polymer called lignin and is structured for mechanical function. These cells provide rigidity to the plant body.

Complex Tissue

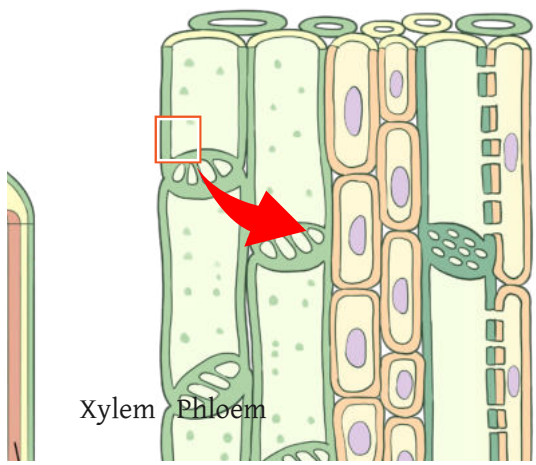
Some permanent tissues are composed of more than one type of cells that work together and perform similar functions. These tissues are known as complex tissues. They are also called transport tissues because they carry out the transportation functions in plants. There are two types of complex tissues:

(a) Xylem Tissue:

Xylem tissue is one of the tissues that give rigidity to plants. Xylem tissue supplies water and other mineral salts from the root through the plant's stem to the upper leaves.

(b) phloem

In the stem of a plant, phloem tissue and xylem together form bundles of transport tissue. Xylem provides water and raw materials for making food while phloem transports the food that is prepared in the leaves to various parts of the plant body.



Xylem Cambium Phloem

Vascular tissue of a plant

The tissue between xylem and phloem is called cambium. This tissue forms new xylem and phloem tissue as a meristematic tissue and helps in the growth of plant's stems

5.2 Importance of plant's organs and their functions

The main structural organs of a plant are roots, stems and leaves which are made up of various tissues. Why are roots and stems essential for plants? Why do plants need roots and stems? Water is transported through pipes to different parts of the different floors of a tall building. Similarly, plants require a system to transport different substances in order to carry out their biological functions. Plants that have this type of transport tissue are known as vascular plants. These plants absorb water and minerals salts from the soil using their roots. The water then moves up through the stem to reach higher branches and other parts of the plant. In the presence of sunlight, plants utilize water and carbon dioxide to produce sugars, and this process also generates oxygen. Oxygen is required for respiration of the carbohydrates into plant's body. Plants release the extra oxygen into the air, which makes a habitable environment for humans and other animals.

5.2.1 Stem

We see various types of trees around us. The part of the tree that we see above the soil is mainly the stem of the tree. The bark of a tree typically appears brown or grey, while the young branches are green. The stem provides structure to the plant and performs essential functions like holding leaves, flowers, and fruits. The part from which leaves are formed is called a node, and the section between two nodes is called an internode. The stem can be different for different plants or for different parts of a tree. What appears as a flower bud is actually a type of soft stem. Initially, the stem is soft and the branchers are weak, but they gradually grow stronger over time. Eventually, the stem becomes very hard and can be used as timber. They have a thick outer layer called bark. The stem gives the plant a specific shape and structure, offering protection. Moreover, tree branches also aid in propagation. Here it is to be remembered that every season a tree grows in roots, tips and sides. Lateral (side) growth causes stems, branches and

Cross section of a teak wood stem shows rings

trunks to thicken and form the rings we see in cross-sections of tree trunks. A ring marks a cycle of seasons or a year.
Certain metamorphosed underground stems like potatoes and ginger take on various shapes and sizes by storing food. The tasty sugarcane juice we enjoy comes from the juicy stems that store food. Similarly, prickly cacti use their stems to store water.

5.2.2 Root

The part of the plant that is connected to the soil, stores food, and absorbs water and mineral nutrients from the soil is known as the root. Roots have tiny hair-like structures called root hairs. Root hairs are formed in such a way that they can easily absorb significant quantities of water and dissolved mineral salts from the soil.

There is a root cap at the tip of each root, which is basically a tough covering of cells that shields the root against injury. Plant roots can be classified into two main types. The part of the root that penetrates deep into the soil is the main root while branch roots spread out closer to the surface. They perform the job of absorbing water and minerals from the soil. When water and mineral elements enter the main root through root hairs, lateral roots and branch roots, a liquid pressure is formed in the root cells. As a result of transpiration pull, water and minerals are then transported from the roots to the upper branches and leaves of the plant with the help of the stem.

5.2.3 Leaf

When we look at a plant, the most prominent part we notice is its leaves. Leaves are the most vital organ of the plant. Leaves contain chlorophyll, the most crucial element for plant's survival. The food that plants need to survive is made in the leaves. Plants have leaves of various colours, sizes and shapes. The structure of leaves is related to their function. Many leaves are flat and wide so that they can absorb the maximum amount of sunlight. Trees, like mango, jackfruit, blackberry, and banyan, have single or simple leaves. On the other hand, plants like rose, neem, and moringa have multiple small laminae, so they are called compound leaves. Certain plants have needle-like leaves,

while others have prickly leaves. Evergreen trees, like pine trees, have green leaves all year round. The outer layer of a leaf is a wax-like coating called cuticle, which helps prevent the loss of the excessive water from leaves during extremely cold or dry weather. The next layer is the epidermis. In addition to their role in food production and respiration, leaves also contribute to the plant's reproduction. Those of you who have seen the leaves of air plant (kalanchoe pinnata) must have seen that new plants can grow from the leaves.

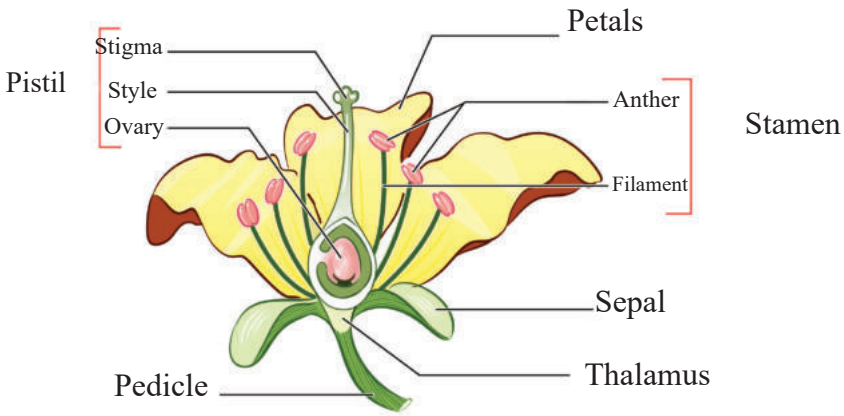
Apart from these three main parts - stem, root and leaf, a plant has the following two other parts too:

5.2.4 Flower

You all must agree that the most charming, scented and colourful part of a plant is the flower. The flower is a special type of modified stem or a section of a stem for plant's reproduction. Flowers produce colours and fragrances to attract pollinators. Different flowers have different fragrances, but two flowers never emit the same fragrance. A typical flower of a higher-level plant is made up of five main parts: receptacle, sepals, corolla, stamens, and carpels. Out of these five parts, stamens, and carpels are the most crucial as they directly participate in reproduction. A flower that contains all five parts is referred to as a complete flower. If any of these parts is missing, the flower is called an incomplete flower. When a flower has both stamens and carpels present at the same time, it is called a bisexual flower. Examples of bisexual flowers are hibiscus and datura. On the other hand, if either the stamen or carpel is absent in a flower, it is called a unisexual flower. Gourd or pumpkin flowers are examples of unisexual flowers.

Stigma

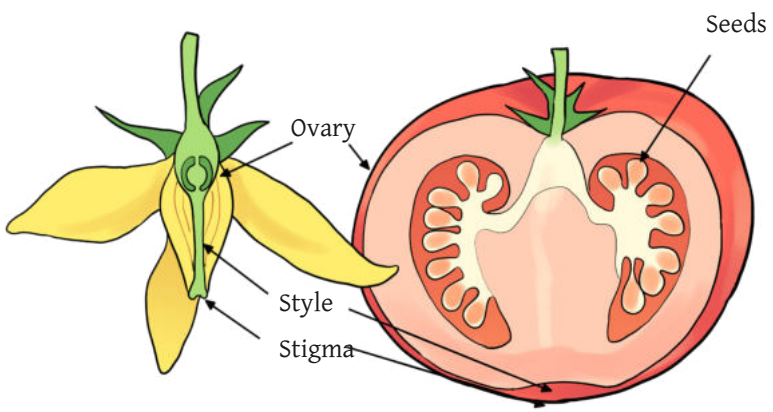
When both stamens and carpels are absent in a flower, it is called a neuter flower.



Bisexual flower

5.2.5 Fruit

Fruits are a distinctive feature of flowering plants. When we think of fruits, we usually mean sweet fruits like mangoes, berries, jackfruits, lychees, bananas, grapes, apple etc. However, all the things that we eat as vegetables, such as gourds, pumpkins, luffas and pointed gourds are actually fruits. In the previous chapter you have learned about the process of fertilization in the ovary of flowers for the purpose of reproduction. Once this fertilization is complete, the formation of fruit begins. After fertilization, the organ formed by the ovary singly or being matured with other parts of the flower is called fruit. When only the ovary of a flower develops into fruits, they are called true fruits. For examples mangoes or blackberries. On the other hand, when other parts of the flower including the ovary, develop into fruits, they are called false fruits (also accessory fruits). Examples of false fruits are apples, elephant apple etc.



When the seed is fertilized, each ovule develops into a seed. Each seed contains a small and undeveloped plant called an embryo. The ovary surrounding

the ovules develops into such a fruit that contains one or more seeds. It is seen in the tomato in the image above.

5.3 Plant Physiology

In every plant cell, many biological functions are constantly performed such as water absorption, osmosis, diffusion, transpiration, transport, photosynthesis, etc. Plants require energy to perform all these biological functions. Plants get energy from food. You already know that plants prepare their own food through a process called photosynthesis. Among these food-making elements, plants get water and minerals from the soil using their roots. They also use their leaves and stems to collect carbon dioxide from the atmosphere. The food that plants make moves to different parts of the plant, helping it grow physically. These functions are carried out in an organized and controlled way. In this chapter, let's learn more about these biological functions in plants.

5.3.1 Diffusion

You might have noticed that when the leaves of a tree planted in the tub droop because of lack of water, they become fresh again after you water the tub. This happens because of diffusion.

When there is a shortage of water in the leaf's mesophyll tissue, the diffusion pressure deficit causes water-deficient cells to take water from nearby cells. This helps the plant's transport system work effectively. When a substance spreads evenly from a more concentrated area to a less concentrated area at the same temperature and atmospheric pressure, it is called diffusion. The force that drives a solvent to move from a higher concentration solution to a lower concentration solution is called diffusion pressure. This diffusion pressure deficit in the leaf's mesophyll tissue causes water-deficient cells to draw water from neighbouring cells. In this way the transport system in the plant remains effective.

Importance:

Diffusion plays a very important role in water absorption of plants. All the physiological functions take place through diffusion system. For example, during photosynthesis, plants take in carbon dioxide from the air and release oxygen. This function is

accomplished through diffusion. Additionally, water that is absorbed by the plant is released from the plant's body in the form of water vapours through transpiration, which also involves diffusion.

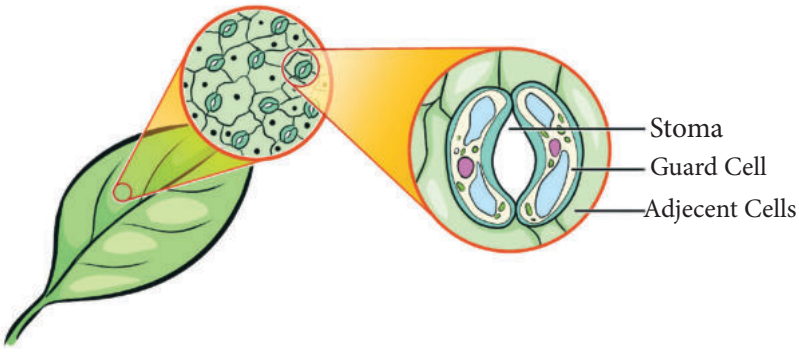
5.3.2 Transpiration

Plants absorb their required water mainly through their roots and only a small amount of this water is used for different biological functions of plants. About 99% of the water comes out mainly through stomata of the plant in the form of water vapours. The physiological process through which the extra water evaporates from different organs of the plant is called transpiration.

Stoma (plural stomata) is a type of pore or hole. In leaves, soft stems, sepals and petals of flowers, the stoma is surrounded by two guard cells. Photosynthesis requires the stomata to be open to take in carbon dioxide and release oxygen. As a result, large amounts of water escape through the stomata as water vapour. A constant flow of water from the roots to the leaves continues due to transpiration. Plants can control excess heat by evaporating water in this process. But at the same time, the process of releasing excess water can cause the plant to suffer from dehydration. We all know that farmers must always ensure adequate irrigation system to protect their crops.

Importance:

Transpiration is a vital process for plants as it plays an important role in supplying water to all the cells and transport the food made through photosynthesis to



A stoma surrounded by two guard cells

different parts of the plant. The pull caused in the plant's outer tubes due to transpiration helps the root hairs to absorb water. Additionally, the transpiration pull helps in lifting up water and food juices, absorbing salts, and delivering minerals to leaves and other parts of plants.

5.3.3 Transport System of Plants

Transport in plants refers to the movement of water and minerals absorbed from the soil and food prepared in the leaves. The water inside the cells and the minerals dissolved in it are together called cell sap. The cell sap travels to the plant's leaves through xylem vessels due to transpiration pull and other processes. When water reaches the leaves, food is produced there. Phloem tissues take the responsibility of transporting the prepared food to different regions of the plants.

Plant's roots absorb water and minerals. This cell sap enters the root through the root hair in osmosis process. Osmosis is the movement of a liquid with lower concentration into a liquid with higher concentration through a semipermeable membrane. Water and minerals absorbed through the root hairs move from one cell to the neighbouring cells in the root hair through the osmosis process. From that cell Water and minerals go back to the neighbouring cells. In this way water and minerals move from cell to cell and eventually reach the xylem vessels. Then they reach the mesophyll tissue of the leaf with the current of transpiration through the transport tissue of the stem.

Food is produced there through photosynthesis. Food made from leaves is transported to different parts of the plant through the sieve-tubes of the phloem. A sieve tube is a thin-walled tube-shaped living cell without a nucleus. Longitudinally they are connected to each other and form a long tube like structure in the plant body. The transverse wall between the two sieve tube cells disappears in places and takes on a sieve-like shape. As a result, food can easily move from one cell to another. Thus, nutrients are supplied throughout the plant through the phloem for sustaining life.

If the xylem vessels or sieve tubes of the phloem become blocked for any reason, the plant will inevitably die. That is why, it can be said that transport is an essential process in a plant's life.

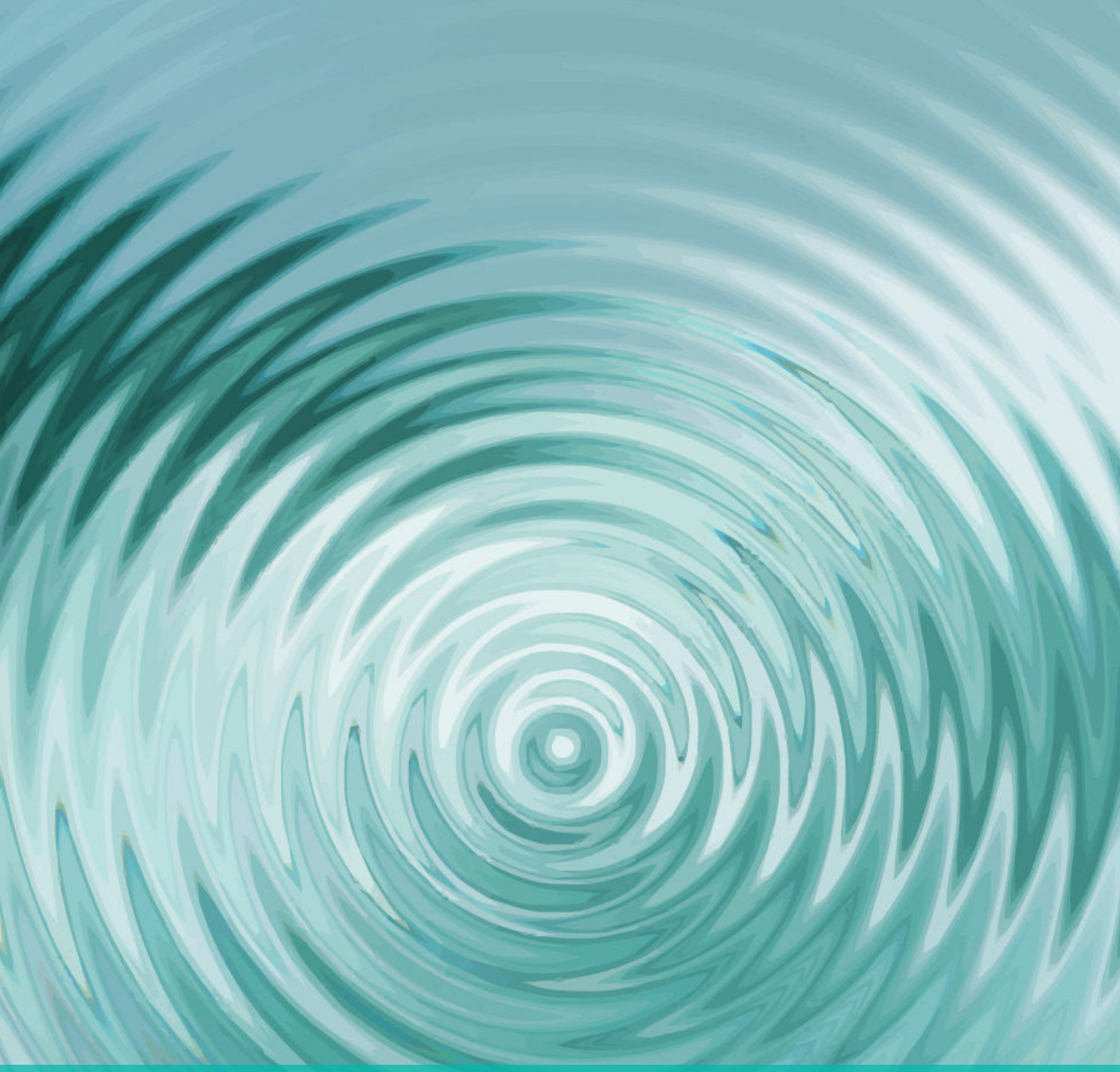
5.4 Plant Tissue Culture and Its Use

Cell division in plants naturally produces tissues as needed, which take part in various physiological functions of plants. Thanks to advancements in science, it is now possible to create plant tissue through artificial methods. Tissue culture refers to the process of

growing a required mutrients. tissue that is isolated from a divisible organ of a plant (such as terminal bud, auxiliary bud, young leaf, or petal) under sterile conditions, along with the necessary nutrients. In other words, tissue culture is the cultivation of plant tissues in the laboratory by providing the Tissue culture allows for the production of a large number of seedlings from a healthy plant. This method of producing many seedlings from very small tissues is also known as micropropagation. Micropropagation is playing a revolutionary role in creating disease-free plants, producing seedlings, preserving nearly extinct plants, achieving faster seedling production, and artificially reproducing plants through embryo culture technology.

Bangladesh has already achieved several successes through tissue culture. Different types of local and exotic orchid seedlings are being produced in the country. Besides banana seedlings, wood apple seedlings, jackfruit seedlings etc. have also been successfully produced. Various pulses and goundnuts have been produced. Disease-free strawberries, stevia, and banana seeds and seedlings produced by tissue culture are also on the list.

Improved potato seedlings have been developed through tissue culture in Rajshahi



CHAPTER 6

WAVE AND SOUND

CHAPTER 6

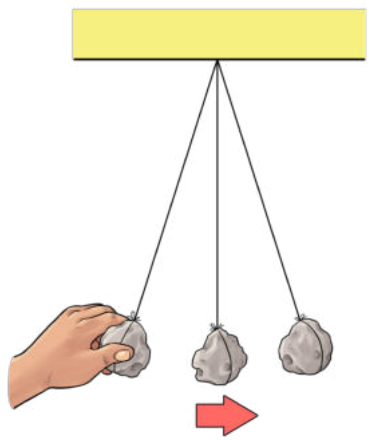
WAVE AND SOUND

This chapter deals with the following topics:

- ☑ Vibration or Oscillation
- ☑ Basics of Waves
- ☑ Types of Waves
- ☑ Wave Variables
- ☑ Sound and its Motion

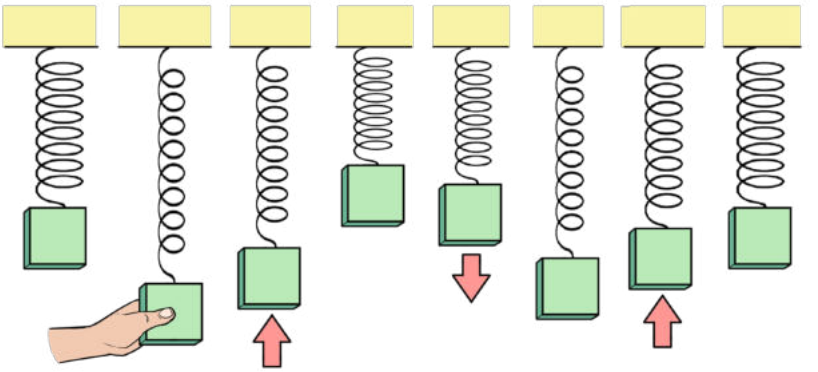
6.1 SIMPLE HARMONIC MOTION

In the previous grade, we learned about a special type of motion called Periodic Motion, where an object moves back and forth in the same position repeatedly. For example, if we tie a stone to a string and let it swing back and forth, the stone returns to its starting position over and over. This is a demonstration of periodic motion. In fact, if there were no friction or any other form of energy loss, the stone would swing indefinitely in the same way. In this type of motion, the movement keeps repeating because the energy of the stone transforms from potential energy to kinetic energy to potential energy again and continues transforming between the two. Initially, when the stone was hanging from the string, it was in a stable position called equilibrium. In this equilibrium position, the stone have neither potential nor kinetic energy. Now, when we pull the stone at one side, it is slightly raised from its initial position, which accumulates potential energy within it. Now, when the stone is released, it cannot fall directly down due to being tied with a string, so it tries to move forward to reach the lowest point. During the motion, the potential energy decreases, and it is transformed into kinetic energy. When



When you tie a string to a small stone, pull it to one side and then release it on one side, it oscillates and remains in a state of transformation between potential energy and kinetic energy.

it reaches the lowest point, that is, at the point where it was in equilibrium, the stone does not contain any potential energy. But now all of the energy have transformed into kinetic energy, which makes the stone reach and move at the highest speed. Notice here, that the stone reached the point where it was in equilibrium, but we cannot call this state an equilibrium anymore since there is kinetic energy inside the stone now.



The natural state of an object hung from a spring is the equilibrium position. When we pull the object downward, potential energy accumulates within it. When released, it starts oscillating up and down. Here, the stored potential energy first transforms into kinetic energy to move it upward, then in turn, it compresses the spring and transforms into potential energy. Then the potential energy converts back into kinetic energy, thus continuing the oscillation causing the spring to compress and expand repeatedly.

Due to this kinetic energy, the stone continues to rise on the other side and gradually loses its kinetic energy. When it reaches up to the highest point again, it stops, and there is no kinetic energy in it left in it. All the energy transforms into potential energy. The stone then changes direction and slowly starts moving towards the other side and this way repeats the entire cycle of motion. In others words, energy alternately transforms between potential energy and kinetic energy in the stone continuing the cycle of motion. This type of motion is known as Simple Harmonic Motion. This is one of the most significant type of motions observed on Earth.

Similarly, if we attach a mass to a spring, pull it down and release, it oscillates up and down. This is another example of Simple Harmonic Motion. When we elongate the spring by pulling it down to its lowest position, we create potential energy within it. If we release the mass, this potential energy is transformed into kinetic energy and again, as in the previous example, this kinetic energy is completely transformed back into potential energy when it reaches the maximum height. The spring generates potential energy and kinetic energy within it when its equilibrium position changes, to either

rarefaction or compression. As the above image demonstrates, the mass undergoes a continuous transformation between potential and kinetic energy, and oscillates up and down.

In simple harmonic motion, the maximum distance a moving object reaches in one direction from the equilibrium position is called the amplitude. The period of simple harmonic motion remains

constant under a certain condition, and it cannot be increased or decreased. To change the period, one has to change the specified conditions. For example, mathematically for a simple harmonic oscillator of length l, we can write the period of oscillation T as:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Here, g is the acceleration due to gravity. From this formula, you can say that by changing only the length of the string, you can change the period of oscillation. In this case, the length of the string is the specified condition under which the period remains unchanged.

6.2 BASICS OF WAVES

You have all seen ripples in water. When somethings falls into a pond, it creates circular waves that spread in all directions from the point of the disturbance. When a boat moves through a river, its bow creates a wave that travels forward and eventually crashes at the shore. If you tie a rope at one end and flick it from the other end, you will see a wave travelling along the length of the rope. Similarly, if you compress a long spring and release it, you can see the compression propagating through the spring. All these examples represent different types of waves. In each of the cases, we have applied some form of energy to create a wave that propagates through a medium and carries that energy from one place to another. However, the notable aspect of waves is that even though the medium carries the energy from one place to another, the medium itself does not change its position. In our examples, the rope, water, or spring, none of them actually changes their location,

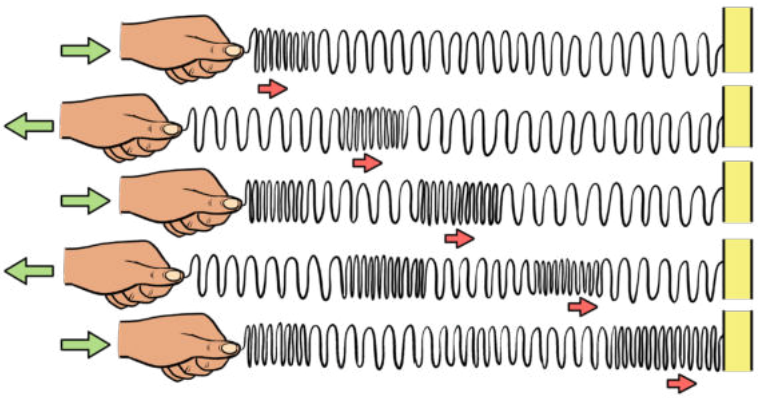
When we drop something into a pond, water waves spread in a circular shape.

but the wave motion travels through them. Sound, which we are quite familiar, is also a type of wave. We cannot see sound, but it uses air as a medium to transmit from one place to another, while the air itself remains stationary.

» A wave is the process of transmitting energy from one place to another through a medium, where different parts of the medium vibrate at their respective positions, transmitting the energy forward but does not change position itself.

6.2.1 WAVES & SIMPLE HARMONIC MOTION

Those of you who have thrown pebbles into a pond and created ripples in the water will have a better understanding of the concept of energy transfer through waves. When we throw a pebble into the pond, the pebble flies with a certain velocity, which means it carries a certain amount of kinetic energy. As the pebble hits the surface of the water, this energy is transferred to the particles of water in that area and creates a disturbance at the point of contact. This disturbance creates a ripple in the adjacent particles of water, which in turn creates a ripple in the particles next to them. This ripple continues to spread, and we can see the formation of a circular ripple expanding from the center like a wave. If you observe a water hyacinth floating on the water, you will notice that when the water wave passes beneath it, the plant floats up and down with the water but doesn't move ahead with the wave. This means that the medium itself did not displace, but only carried the energy of the wave forward oscillating in its place.



One end of the spring is stretched or compressed to create a longitudinal wave through it.

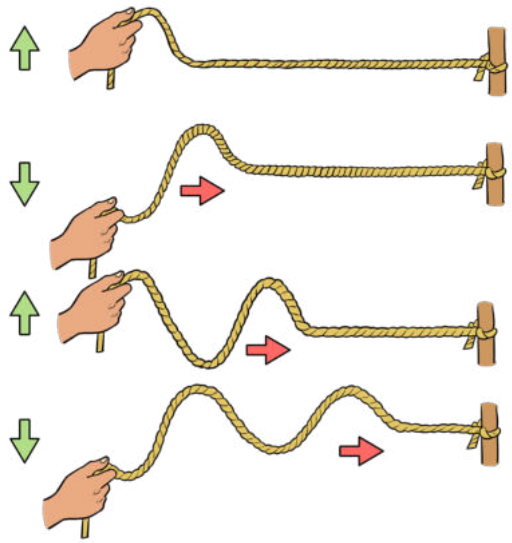
Now you'll find it easy to understand the relationship between waves and simple harmonic motion. If you focus on a specific point within a medium when a wave travels through it, you will observe that the point undergoes a simple harmonic motion by oscillating in place. When a specific point in the medium undergoes simple harmonic motion, it generates that motion in the adjacent points and they do to the next points

and so on, thus creating a wave. The simple harmonic motion is not the wave itself, but each point of the wave undergoes separate simple harmonic motions.

Although we have talked about a medium in the context of wave, there are some waves that don't require a medium for their propagation. Light is an example of one such wave, and we know that light from the Sun reaches the Earth without any medium in space. In this chapter, we will confine our discussions to the waves requiring a medium for their propagation.

6.2.2 TYPES OF WAVES

You surely realized by now that the most important aspect of waves is the transference of energy through a medium from one place to another without itself changing its position. The particles of the medium can undergo two types of vibrations. When one end of a spring is firmly fixed at a place and the other end is moved back and forth at regular intervals, you will observe a wave with alternate compressions and rarefactions propagating through the spring. This compressions and rarefactions are called the oscillation of the spring. If you pay a little attention, you will notice that the wave created inside the spring corresponds to the direction of the oscillation of the spring. This type of wave is called a longitudinal wave. Sound is also a longitudinal wave that propagates through the air by compression and rarefaction.



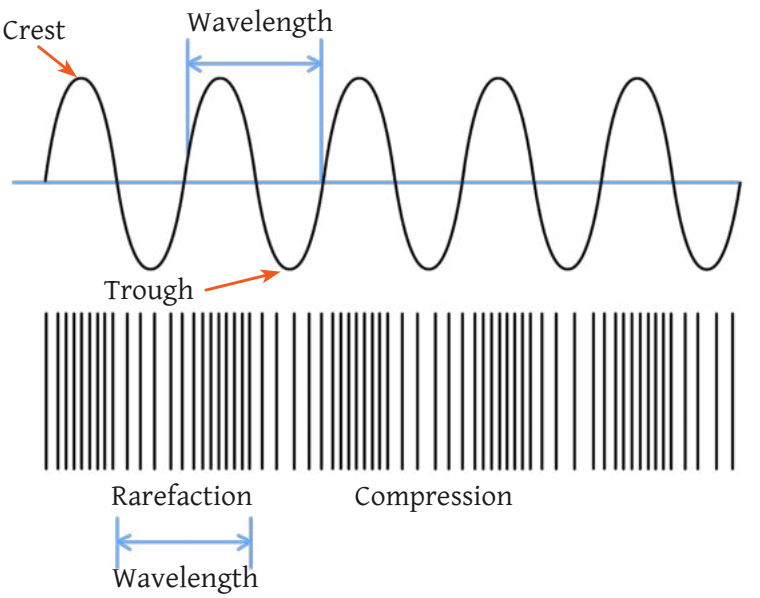
One end of the rope is flicked up and down to create a transverse wave along it.

Now, imagine that if one end of a long rope is fixed tightly and the other end is flicked up and down on with regular intervals, what do you think will happen? You will observe a wave propagating through the rope also in this case, however, this time the rope will rise upwards and come downwards, taking the wave along with it. Notice that here the oscillation or vibration of the rope occurs perpendicularly to the direction along which the wave travels. This type of wave is called a transverse wave. The ripples on water are an example of a transverse wave. Even though we can see light, we cannot see its wave but that is also a type of transverse wave. Can you identify the transverse and longitudinal waves among the different types of waves around you?

» When the wave propagation and the oscillation of its medium happens in the same direction, it is called a longitudinal wave. When the medium of the wave oscillates perpendicular to the direction of the wave, it is called a transverse wave.

6.2.3 WAVE VARIABLES

The images demonstrate a longitudinal and a transverse wave. The two waves appear distinctly different, but there is a significant similarity between them, which is that their medium undergoes periodic oscillation. In the transverse waves, the highest part above the point of equilibrium during vibration or oscillation is called the crest and the lowest part below is called the trough. Similarly, in the longitudinal waves, the part that remains more compressed than the equilibrium state is called the compression, while the portion that remains more stretched is called the rarefaction. The distance between the start of one crest to the end of the next trough is called a 'wavelength'. Since wavelength is a distance, it is measured in typical units of length or distance, such as, centimeters, meters, etc. In mathematics and scientific notation, the Greek letter λ (lambda) is commonly used to represent wavelength.



The length between the start of one crest to the end of the next trough is a 'wavelength'

You may have noticed that both in the cases of the rope or the water wave, it takes some time for energy to propagate through the medium. In the case of sound or light, we can't perceive it properly but even there, it takes time for the wave to travel from one place to another. The time required by the wave to move a distance of one wavelength is called a 'period'. Since it is a measure of time, general units of time such as second, minute, etc. are used for it. The English letter T is the symbol typically

used to denote period in mathematical expressions. On the other hand, the number of wavelengths passing through a particular point in one second is called the 'frequency'. In mathematical notation, frequency is represented by the letter f and is measured by the unit Hertz (Hz). Therefore, we can say that the higher the frequency, the more oscillations there are in a wave. We can also say that the lower the frequency of a wave, the longer its period, because frequency represents the number of cycles per second, so:

$$f = \frac{1}{T}$$

Since the unit for T is second (s), it is clear that Hertz is actually represented as s^{-1} or 'per second'. Therefore, when we say the frequency of a wave is 100 Hertz, it means that if we observe a specific point within the wave, we will see its amplitude oscillating 100 times per second.

You may have noticed by now that we used several variables of waves before in the study of simple harmonic motion. Both waves and simple harmonic motion have a period of oscillation, both can have a measurement of frequency and the idea of amplitude is applicable to both cases as well. However, the wavelength is a variable relevant only in the study of wave, not for simple harmonic
motion. Similarly, the velocity of a wave refers only to the wave's propagation and does not apply in the case of simple harmonic motion.

The distance travelled by a wave in one second is its velocity. Since a wave traverses a distance of f number of wavelengths per second, that means, it traverses a distance $f\lambda$ per second. Therefore, the velocity of a wave v is:

$$v = f\lambda \text{ m/s}$$

Wave Velocity = Frequency × Wavelength

Since the speed of a wave is specific for a specific medium, the more the frequency the wave, the less the wavelength will be, and conversely, the greater the wavelength, the lower the frequency will be. The frequency of a sound wave determines its intensity, and the frequency of light waves determines the color of the light. Red light has a higher frequency, so its wavelength is relatively shorter. On the other hand, blue light has a lower frequency, so its wavelength is relatively longer.

6.3 ORIGIN OF SOUND

Everyone has presumably seen a metal plate sometime. If you've ever dropped a metal plate, then you know what a clanging noise it makes. If you can find such a plate now, then hold one end of it firmly with your hand and strike the middle with a spoon. You

will hear a metallic sound. If you look at it closely, you will notice that the plate is vibrating. Now, if you place your hand on the plate to stop the vibration, you will notice that the sound stops as well. So we can understand that there is a relationship between vibration and sound. If you touch your throat while speaking, you will feel a vibration. This happens because we produce the sound for speech by vibrating a membrane called the vocal cord. 'Sound' can be generated from the vibration of any object, which humans or other animals perceive through their ears.

Sound is actually a longitudinal wave created by the propagation of vibration from an object through a medium adjacent to it. Although vibrations of all frequencies are not audible, that is, they are not sounds. Typically, humans can hear frequencies ranging from 20 Hertz to 20000 Hertz. The ears of some other animals can be even more sensitive and perceive sounds beyond human ears can. Vibrations with frequencies lower than 20 Hertz are called subsonic vibrations and with frequencies higher than 20,000 Hertz are called ultrasonic vibrations.

Cat can sense 48 Hz to 85,000 Hz

6.4 VELOCITY OF SOUND

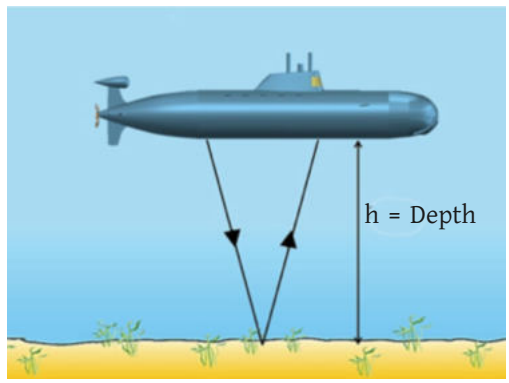
We have just learned that waves have velocity. Since sound is also a wave, it has a specific velocity through a specific medium. Since compression and rarefaction occur differently in different mediums, the speed of sound also varies depending on the medium. You have already learned that in solid substances, the particles are tightly bound together as a unit block. That is why the vibration very quickly propagates through a solid substance to the other end. That is why the speed of sound is the highest in solid mediums. On the other hand, the particles in a fluid substance are loosely connected to each other. Therefore, when there is a vibration at one end of a fluid substance, it takes a little longer for that vibration to reach the other end. So, the speed of sound is lower in fluid mediums than the solids. Gaseous substances have their particles in a relatively free state, so it takes the longest time for compression and rarefaction created in one end of a gas to reach the other end. In other words, the speed of sound in gaseous mediums is the lowest. So you can see that the same sound travels at different speeds through different mediums. The speed of sound through the air is 332 m/s; in water, it is 1481 m/s which is about four times higher, while in iron, the speed of sound is 5120

m/s which about three times higher than in water!

Example: A sound of a certain frequency can be produced by vibrating a tuning fork. If a tuning fork with a frequency of 830 Hz is vibrated, what will be the wavelength of the resulting sound? (Assume the speed of sound in air is 332 m/s)
Solution: Here, the frequency of the tuning fork f = 830 Hz, and the wavelength of the wave, λ =40 cm=0.4 m, we need to find the wavelength λ of the sound.
Since, velocity of sound, $v = f\lambda$ Or, $\lambda = v/f$ So,

$$\lambda = \frac{332}{830} = 0.4m$$

Since sound is a type of wave propagates in the form of vibrations, so when sound waves encounter an obstacle, they bounce back or reflect just as other waves do. When that happens, sometimes the same sound can be heard again. This phenomenon is called an echo. For this reason, when we produce a sound in a large empty space, it creates a type of reverberation or resonance and we hear the sound as a rumble. Even if sound is produced against a large wall or in front of a mountain at a considerable distance, clear echoes can be heard. Echoes can also be produced at the mouth of a deep well. To produce an echo, sound has to travel the distance from the source to the obstacle and travel back the same distance. That is, the sound has to travel twice the distance between the source and the obstacle. If we can precisely measure the difference in time between the original sound and the echo, then we can determine the speed of sound from that. So, if the obstacle is located at a distance d from the source, and the time difference of between the sound produced and the echo is t, then:



Submarine measuring the depth from the echo time of a sonar.

$$\text{Speed of sound } v = \frac{\text{Distance Travelled}}{\text{Required Time}} = \frac{\text{Twice the distance between source \& obstacle}}{\text{Time difference between original sound \& echo}} = \frac{2d}{t}$$

Example: A person cannot distinguish between two sounds heard within 0.1 seconds of each other. What should be the minimum distance from the source to the obstacle to hear an echo?

Solution: After the sound is produced, it has to take at least 0.1 seconds to reflect and return to the point of the source. Assuming the speed of sound to be 332 m/s, we can calculate that the sound needs to travel at least 332 x 0.1 = 33.2 m. Since the sound needs to travel twice the distance from the source to the obstacle to produce an echo, the actual distance will be half of 33.2 m, which is approximately 17 meters.

Alternatively, if we already know the speed of sound through the medium, we can calculate the distance d of the obstacle from the source by determining the time it takes for the reflected sound to return as d $d = vt/2$

$$\text{Distance between Source and Obstacle} = \frac{\text{(Velocity of Sound in the medium} \times \text{Time difference between Sound and Echo)}}{2}$$

That means, by measuring the difference in time between a sound and its echo, we can determine the distance of the obstacle. In fact, this is the method used to navigate underwater submarines. The device used to precisely measure this distance is called a sonar. Even in nature, bats use this method to determine the distance to their prey or that of obstacles during movement. Sonar is also used to measure the depth of oceans. Scientists use the same method to determine the depth of the underground water level or that of various mineral substances.

Example: If you stand a certain distance away from a mountain and clap your hands, and you hear the sound of another clap exactly 6 seconds later, can you determine how far you are from the mountain? (Assume the speed of sound in air is 332 m/s.)

Solution: Here, the given speed of sound in air, v = 332 m/s and the time elapsed, t = 6 s. We need to find the distance d.

We know, d =vt/2=(332 × 6)/2=996 m

So, the distance of the mountain from the source of sound is 996 meters.

$$d = \frac{vt}{2} = \frac{332 \times 6}{2} = 996\ m$$

Chapter 7

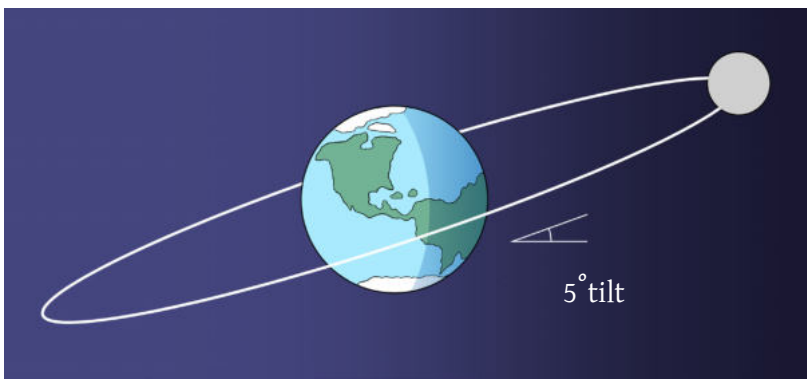
Sun, Earth and Moon

Chapter 7 Sun, Earth and Moon

This chapter deals with the following topics:

- ☑ Creation of the Moon
- ☑ Position of Sun, Earth and Moon
- ☑ Penumbra and umbra
- ☑ Solar Eclipse
- ☑ Partial, total and annular solar eclipses
- ☑ Momentary effects on the environment: animals and birds and temperature
- ☑ Solar observation and research opportunities, Analemma
- ☑ Lunar eclipse: Total and partial lunar eclipses
- ☑ Red moon
- ☑ Distance between Earth and Sun
- ☑ Perihelion, Aphelion
- ☑ Change in Earth's rotation axis

In our previous class, we learned a lot about solar and lunar eclipses. In this chapter, we will discuss solar and lunar eclipses in a bit more detail. During an eclipse, the sun or the moon gets temporarily covered in the sky. The Earth's orbit around the Sun is not exactly circular, but rather slightly flattened or elliptical. As a result, the distance from the Sun to the Earth is not always the same. It takes the earth 365 days 5 hours 48 minutes 47 seconds to complete one full revolution around the sun. We call this amount of time a year on the earth. Just as the earth revolves around the sun, the moon also revolves around the earth in an elliptical orbit. However, the moon's orbit is inclined (tilted) by about 5°



compared to the earth's orbit. It takes a little over 27 days (27.3 days) for the moon to go around the earth once. However, it takes an additional two days to complete a lunar month because the earth covers a slightly greater distance around the sun in 27.3 days. The earth has to wait for two more days in order to move to its new position after crossing this distance to observe the new moon at the beginning of the lunar month. Earth's revolution around the sun and the moon's revolution around the earth cause various natural phenomena, some of which are discussed below.

7.1 Origin of Moon

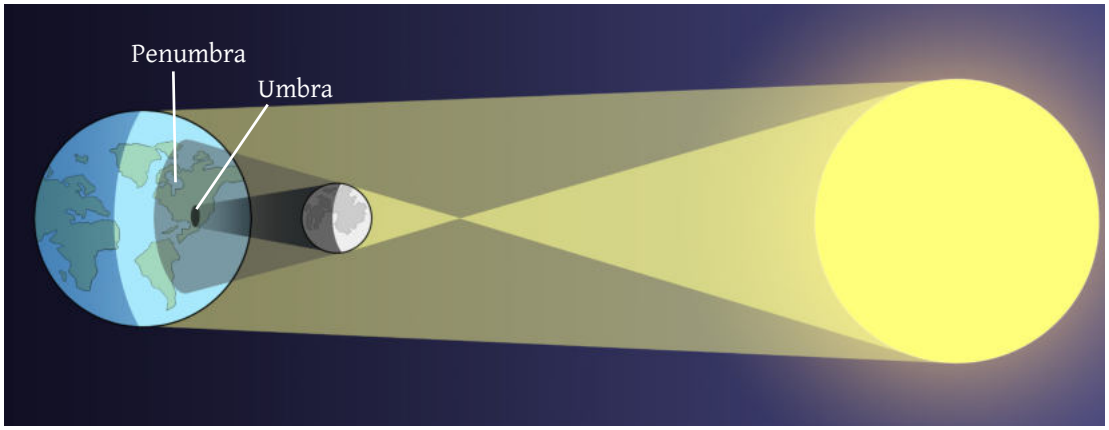
There are several different theories about the origin of the moon. But the most accepted hypothesis today is the 'collision' theory. Analysis of the moon's soil brought back from the moon after the mission to the moon has found surprising similarities with the earth's soil. That is why it is assumed that during the initial period of the formation of the solar system, there was a terrible collision between the Earth and a planet about the size of Mars called 'Theia'. In that collision, a part of the Earth was ejected and began orbiting the Earth, which we now call the Moon. Those of you who have looked closely at the moon must have noticed that the moon always orbits with one side facing the earth, so we always see one side of the moon and never the other side.

7.2 The Position of Sun, Earth and Moon

The sun is approximately 109 times larger in diameter than the earth. Again, the moon's diameter is only 27% of the earth's diameter. This means that sun's diameter is around 400 times larger than that of the moon. On the other hand, the average distance between the earth and the sun (1,500 lakh km) is 400 times greater than the average distance between the earth and the moon (3.84 lakh km). During solar and lunar eclipses, the sun, the earth and the moon remain in the same straight line. As a result, sometimes, earth's shadow falls on the moon, which is called a lunar eclipse. Again, moon's shadow falls on the earth, which is called a solar eclipse. These shadows are formed when the earth or the moon blocks sun's light. If the light source is a point, it produces sharp shadows. However, as the sun is so large, it casts two types of shadows- the penumbra and the umbra.

Penumbra

When an object blocks a portion of the light source and creates a shadow, but another part of the light source falls in this shadow and partially illuminates it, it is called a penumbra. This is why this shadow is partially dark. Naturally, the penumbra covers a large area.



During a solar eclipse, the sun, the moon and the earth remain in the same straight line. As a result, the penumbra and umbra of the moon fall on the earth surface. A total solar eclipse is shown here.

Umbra

When an object completely blocks the light from a source due to the position of the object and creates a shadow, it is called an umbra. This shadow is dark in nature. During an eclipse, the umbra region is covered by complete darkness for a period of time. The umbra occupies a smaller area than the penumbra.

7.3 Solar eclips

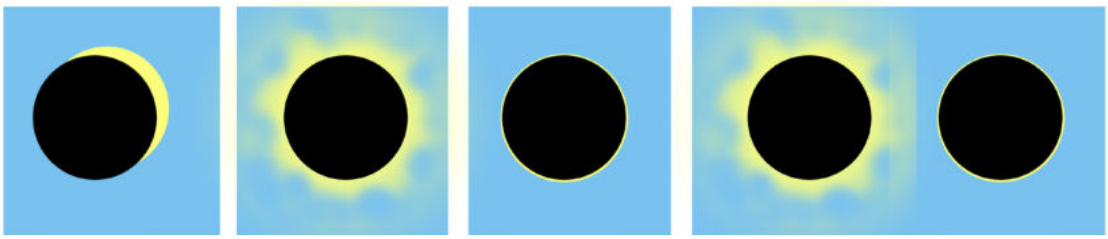
When the moon comes between the sun and the earth as moon orbits the earth, the moon blocks sun's light from reaching the earth. As a result, the shadow of the moon falls on certain areas of the earth. This event is called solar eclipse. During a solar eclipse, the sun, the moon, and the earth are aligned in the same straight line. Solar eclipses can be of different types, such as, partial, total, annular, and hybrid. You might wonder how the moon can cover the sun even though The diameter of the sun is 400 times larger than the diameter of the moon. This is very simple, because although the sun is much bigger than the moon, the moon is 400 times closer to the earth than the sun. As a result, the moon and the sun appear to be nearly the same size from the earth's surface. The orbit of the moon is slightly elliptical. When it is closest to the Earth, the distance from the Earth to the Moon is 3.63 lakh km. When it is furthest from the Earth, the distance from the Earth to the Moon is 4.05 lakh km. The maximum distance between the moon and the earth is called apogee and the shortest distance between the moon and the earth is called perigee.

7.3.1 Partial solar eclipse

When the moon is positioned between the earth and the sun, if only a portion of the sun is obscured by the moon, then a partial solar eclipse occurs. In this case, the sun appears

partially obscured by the moon in areas where the eclipse can be observed. During this eclipse, the penumbra is mainly dominant.

7.3.2 Total solar eclipse



Different types of solor eclipse: a) Partial b) Total c) Annular and d) Hybrid

A total solar eclipse happens when the moon fully obscures the sun during the eclipse. In this situation, a total solar eclipse can be observed from all the areas where the shadow falls. During a total solar eclipse, the corona of the sun becomes visible around the moon and this corona can be seen with the naked eye, which cannot be observed during any other time. We know that the moon orbits the earth in an elliptical path. As a result, sometimes, the moon comes closer to the earth (perigee) and the moon appears relatively large. If a solar eclipse occurs when the moon is in perigee, it is a total solar eclipse.

Diamond Ring created at the beginning and end of a total solar eclipse.

The umbra covers only a tiny area and the earth also rotates on its own axis. As a result, the umbra is not confined to a specific place but moves along a line on the earth's surface (which we may call a total eclipse line). A total solar eclipse can be witnessed in all the places where this line falls on earth's surface. During the very beginning of a total solar eclipse, when the entire sun gets covered and only a small part remains uncovered and after the end, when a small part comes out after the total cover, the intense light of the sun is visible in that part and it looks like a diamond ring. This effect is called the diamond ring.

7.3.3 Annular solar eclipse

While traveling in its elliptical path, the moon sometimes is positioned in a way that it cannot completely cover the sun during a total solar eclipse. In that case, the sun appears as a golden ring around the moon. This type of ring-shaped solar eclipse is called an annular solar eclipse.

Question: Is it ever possible that during a solar eclipse there will be a total eclipse at some place, a partial eclipse at some place and an annular eclipse at some place at the same time?

7.3.5 Effects and Importance of Solar Eclipses:

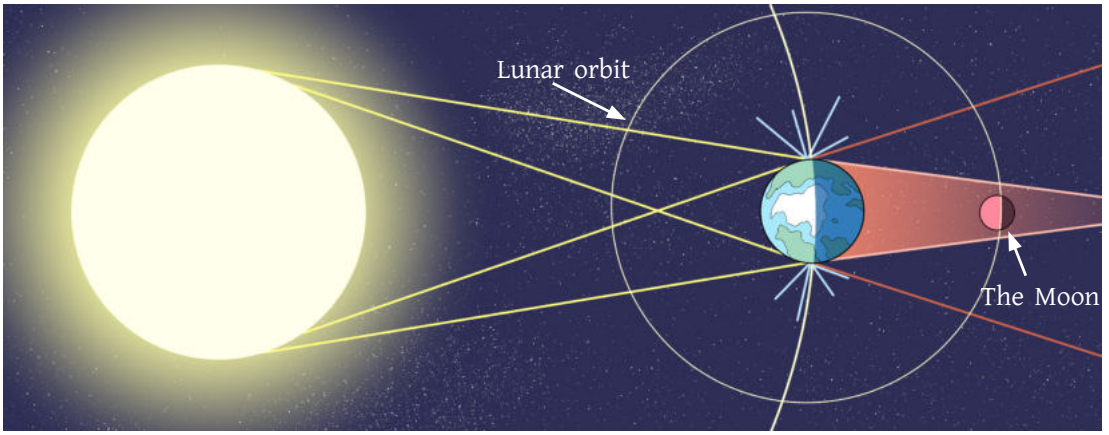
Solar eclipses have temporary effects on the environment. When a total solar eclipse happens, the Sun gets completely covered for only a few minutes. However, the partial eclipse can last for a longer time. During the eclipse, animals may get startled by the sudden darkness. Due to the darkness, birds might stop calling, insects may start making noise, and plants might begin to droop. In some areas, the air temperature may also decrease slightly.

But solar eclipses create rare opportunities for solar research. For example, solar eclipses give the best opportunity to gather information about sun's corona. During a solar eclipse, we can observe the corona from earth's surface because it lies outside earth's atmosphere and gets covered by the moon. Additionally, we can study earth's atmosphere, especially its upper part, during an eclipse. various types of charged particles are formed in the outer part of the atmosphere due to sun's radiation. It is crucial to observe this region as it houses many man-made satellites.

7.3.6 Solar eclipse observations and precautions:

It is important to remember that the sun emits many harmful rays that reach the earth. One of them is ultraviolet rays. Since we can't see ultraviolet rays, we can harm our eyes looking at them without knowing. Looking directly at the sun can cause permanent eye damage in a few seconds. The safest way to watch a solar eclipse is by not looking directly at the sun, but by reflecting its light onto another surface. One easy method to observe a solar eclipse is by using a pinhole. A solar eclipse can be seen by cutting a small hole in a piece of cardboard and reflecting the sunlight onto another screen during an eclipse.

7.4 Lunar Eclipse:



The blue part of the Sun's light is scattered outwards by the Earth's atmosphere, making the interior light appear reddish. During a total lunar eclipse, the moon appears reddish in that light.

While orbiting the earth, the moon sometimes gets in such a position where the earth is in the middle of the moon and the sun. In this case, the sun, the earth and the moon stay in a straight line. As a result, earth's shadow falls on the moon and a lunar eclipse occurs. During a lunar eclipse, sometimes earth's penumbra or umbra or sometimes both fall on the moon.

Lunar eclipses can be of three types: Total lunar eclipse, Partial lunar eclipse and Penumbral lunar eclipse.

7.4.1 Total lunar eclipse

Different types of lunar eclipses as seen from the earth: penumbral, partial and total lunar eclipse respectively. It is noticeable that during a lunar eclipse, the moon looks different from its natural whitish-grey colour.

During a lunar eclipse, the moon stays in the middle of earth's umbra. During this time, rays of sunlight with relatively short wavelengths (such as, lights of violet, blue, etc colours) are scattered outwards by earth's atmosphere. On the other hand, the red light of longer wavelengths is refracted inward and falls on the moon, making the moon look redder than its normal whitish-grey colour. When a lunar eclipse occurs during a full moon, it is not observed in every full moon because moon's orbit is inclined by about 5^0. A lunar eclipse lasts longer than a solar eclipse.

7.4.2 Partial lunar eclipse

During a partial lunar eclipse, the sun, the earth, and the moon are positioned in a way that some parts of the moon are hidden by earth's penumbra, while other parts are covered by the umbra. In this case, some parts of the moon are seen to be covered with dark shadows.

7.4.3 Penumbral lunar eclipse

A penumbral lunar eclipse is observed when the moon moves through earth's penumbra. As the penumbra is lighter than the umbra, this type of lunar eclipse is not easy to see unless you observe closely. At this time, the moon appears slightly darker than its normal colour.

7.5 Analemma

If you ever have noticed the shadow of a building, wall, window, or any other structure in the same place at the same time regularly, you must have observed that it doesn't appear in the same spot every year. Its position slowly shifts during different seasons of the year. This happens because the sun does not stay at the same place in the sky at the same time every day. On 21 June, the sun is exactly perpendicular to the Tropic of Cancer, which passes through Bangladesh. This makes the Sun appear directly overhead, moving from east to west. As time passes, the Sun starts moving towards the south. After six months, on 22 December, the sun is exactly perpendicular to the Tropic of Capricorn.

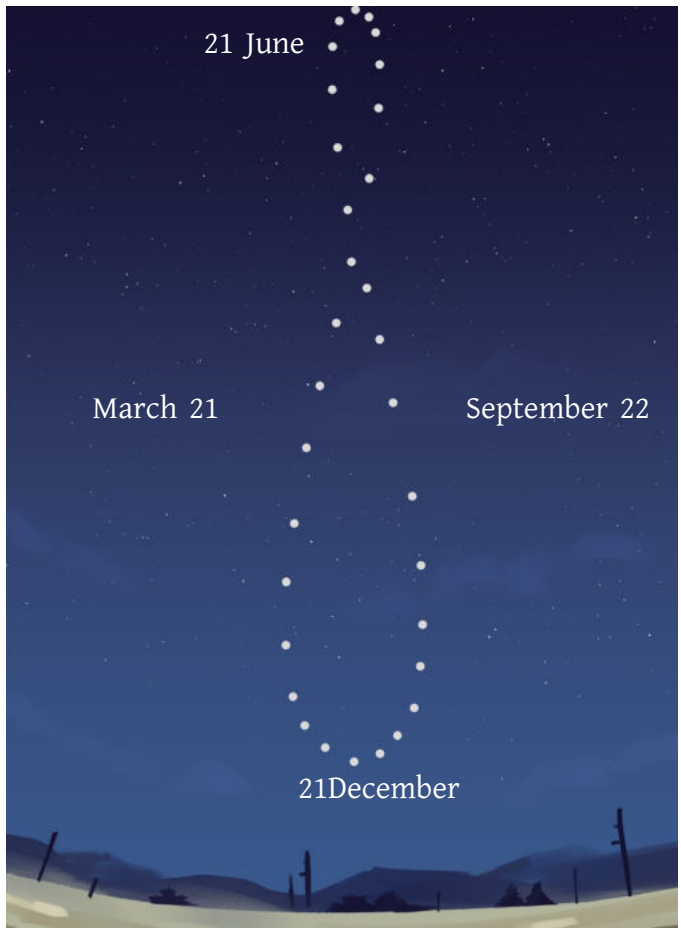
So, we see the sun moving from east to west at its greatest declination. Then, the sun starts moving back towards the north again, and after another six months, it again passes directly overhead from east to west.

If you take a picture of the sun at the exact same point in the sky at the same time each day and then put all the pictures together after a year, you will see the change in the position of the sun, as shown in the picture next to it. This periodic positions of the sun in the sky at different times of the year is called analemma. The analemma shows the sun's position changes due to earth's elliptical orbit around the sun and the tilt of its axis.

The shape of the analemma is similar to the number four in Bengali or the number eight in English.

You might have noticed that the lower loop of the analemma is bigger than the upper loop. If earth's orbit around the sun were circular rather than elliptical, then both loops would be equal in size.

Again, if the orbit would be elliptical but if earth's axis were upright instead of tilted at 23.5 degrees, then the analemma would be a straight line. If there were a vertical axis and a circular orbit at the same time, we would have no shape of an analemma. Then, the sun would remain in the same position at a certain time throughout the year.



Analemma is obtained by photographing the sun at a specific time in the sky at a specific time interval throughout the year. Analemma looks like 8. It indicates the position of the sun at a particular time of day throughout the solar year.

Analemma is a fascinating subject that astronomers have been studying for hundreds of years. It can be used to figure out the latitude, longitude, date and time of a specific location. But that's not all—it's also used to identify changes in earth's orbit and axial tilt over time.

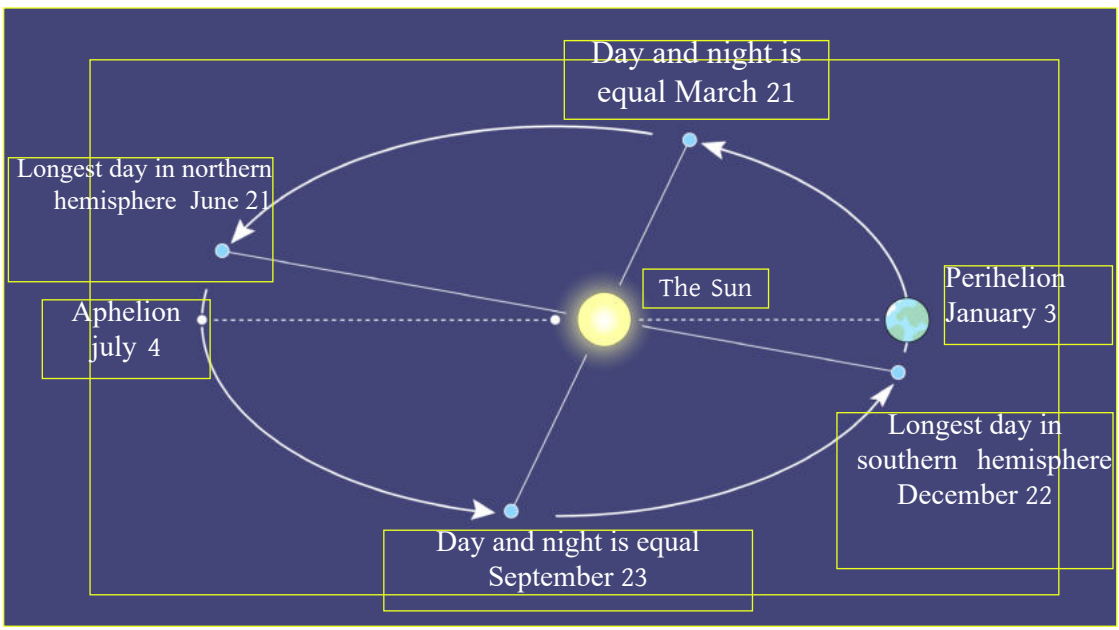
7.6 Change in Earth's Orbit and Axis:

The rotation of the earth around its own axis is called the diurnal motion and earth's rotation around the sun is called annual motion. The imaginary line along the north and south poles of the earth is earth's axis. This axis is inclined at an angle of 23.5^0 with

respect to the plane of earth's orbit. The earth with this tilted axis travels in an elliptical orbit around the sun. Even though we don't notice any change in this orbit or tilted axis in our everyday lives, the elliptical orbit and tilted axis of the Earth are actually changing very slowly. As earth's orbit and tilted axis are responsible for seasonal changes and the length of daylight hours, subtle changes in orbit and axis have significant effects on long-term climate and surface of this planet.

7.6.1 Change in orbit:

The Earth goes around the sun in an elliptical orbit. This means earth's distance from the sun is not always the same. Sometimes it gets a bit closer to the Sun, and other times it moves a bit farther away. The point in the orbit at which the earth is closest to the sun is called Perihelion, and the point at which it is farthest from the Sun is called Aphelion. Perihelion occurs in early January, when the distance between the sun and the earth is 14.7 crore kilometres and Aphelion occurs in early July, when the distance between the sun and the earth is 15.2 crore kilometres. When the earth is at perihelion, it gets about 7 percent more solar radiation than at aphelion, even though it's only 3 percent closer to the Sun. This might seem like a small difference, but it can have a significant impact on earth's climate.



Earth's closest position to the sun is called Perihelion and the farthest from the sun is Aphelion

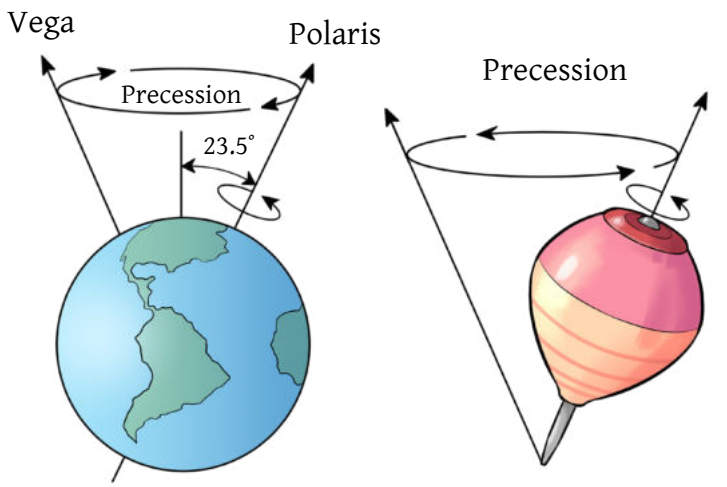
Although the Earth's orbit is said to be elliptical, it is in fact nearly circular today. However, the shape of this orbit does not always remain the same. Every 90,000 to 100,000 years, the Earth's orbit changes from a nearly circular shape (i.e. when the difference in distance from the Sun to the Earth is the smallest in the Perihelion and Aphelion) to a maximum elliptical shape (i.e. when the difference in the distance from the Sun to the Earth is the greatest in the Perihelion and Aphelion). During the highest elliptical orbit, the difference in the amount of solar radiation received by the earth's Perihelion and Aphelion can be from 20 percent to 30 percent. Therefore, the difference in the Earth's weather will be highest during these two positions.

7.6.2 Precession

If you have ever watched a spinning top, you may have noticed that it doesn't spin perfectly straight. It wobbles a bit. Earth's axis is similar to the top's wobbling. Top's head wobbled around and forms an imaginary circle in the void above its head before returning to its starting position.

Similarly, earth's axis makes a circle in the celestial sphere and goes back to its original position every 26,000 years. The point or star along which the North Pole of the earth is located is called a Pole Star. The Pole Star actually change its position over time due to the change in earth's axis. This rotation of earth's axis is called the 'precession of earth's axis'.

As the north pole of the earth presently points towards the star Polaris, Polaris is our pole star. 14,000 years from now it will point towards the star Vega, which will be the new pole star.

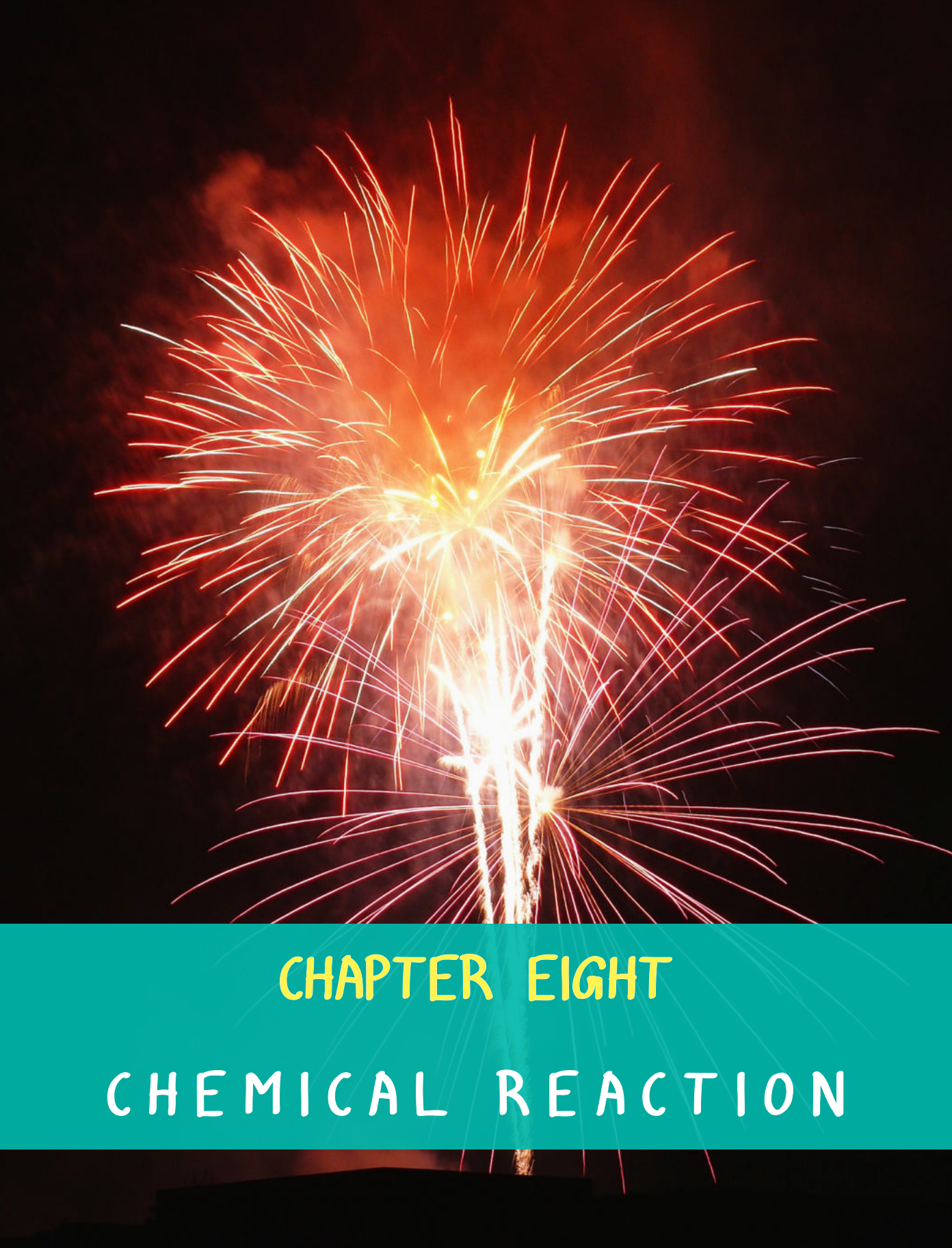


Earth's axis rotates once in 26 thousand years. The axis is currently tilted 23.5^0 changing between 22.5^0 and 24.5^0 every 41 thousand years.

7.6.3 Obliquity :

We already know that earth's axis is tilted 23.5^0 with respect to the plane of its orbit. The measurement of this tilt with respect to the orbit is called the obliquity of earth's axis. This tilt of earth's axis also changes very slowly. Currently, the obliquity of the Earth's axis is 23.5 degrees, but it is slowly decreasing. Over a cycle of approximately 41,000 years, the obliquity of earth's axis varies between 22.1 degrees and 24.5 degrees. The greater the obliquity, the greater the climatic differences in seasons. This means that when the obliquity is higher, summers tend to be hotter and winters tend to be colder.

Question: Earth's orbit becoming more elliptical, Earth's axis precession, and decrease and increase in the Obliquity of Earth's axis, which of these three changes will affect the climate the most and why?



CHAPTER EIGHT

CHEMICAL REACTION

CHAPTER 8 CHEMICAL REACTION

This chapter deals with the following topics:

- ☑ Symbol, Formula and Valency
- ☑ Chemical Equations and different types of Chemical Reactions
- ☑ Chemical Change
- ☑ Transformation of Energy in Chemical Reactions
- ☑ Conservation of Mass during Chemical Reactions

Different types of chemical reactions happen around us all the time. Iron rusting, something burning, or our body digesting foods—all these are chemical reactions. Scientists create new substances through various types of chemical reactions in laboratories. These various types of chemical reactions sometimes generate energy, and at other times, they are used to create new medicines. We will discuss various topics that help us understand chemical reactions.

8.1 SYMBOL, FORMULA, VALENCY

In the previous grades you've already learned that scientists have divided all the matters on Earth into two main categories. Elements and compounds. Scientists have discovered 118 elements so far. The elements are generally written as one or two first letters of their names instead the full names for ease of use. These abbreviated form of their English or Latin names are called Symbols. Some examples are: H for Hydrogen, O for Oxygen etc.

Some elements and compounds are also represented by their Formulas. Formulas tell us how many atoms are there in its molecule. For example, H_2 is the formula for Hydrogen molecule (Hydrogen contains two atoms in its molecule), HCl is the formula for Hydrogen Chloride molecule (there is one Hydrogen atom and one Chlorine atom in the Hydrogen Chloride molecule).

To know the formula of a compound, we need to know about its valency. Elements chemically bond with each other to form compounds and valency tells us how one elements bonds with another. Think of the valency of elements as their hands. The

valency is the number of hands an

element has. For example, Hydrogen and Chlorine both have a valency of 1, so we can think of them as elements with one hand. That means, one hand of Hydrogen atom holds one hand of Chlorine atom. So the formula of Hydrogen Chloride is HCl. Valency of Oxygen is 2, which we can imagine as an Oxygen atom with two hands. It can hold two Hydrogen of valency one or one hand. That is why the formula of water is H_2O.

Hydrogen Chloride and water molecules are shown below:

H-Cl	H-O-H
(Hydrogen Chloride)	(Water)

The above examples show that the valency of an atom is the number of Hydrogen atoms it can hold. It should be noted that when a compound is formed, all the valencies should be used up.

Do it yourself:

Valency of Nitrogen is 3 and Carbon is 4. Can you write the formula for Ammonia from the valencies of Nitrogen and Hydrogen? Similarly, can you write the formula for Methane from the valencies of Carbon and Hydrogen?

Note that some elements can have more than one valency. For example, valency of Sulphur is both 2 and 4, and Iron is both 2 and 3. The following table shows some elements with their symbols and valencies:

Table: Name of Elements, their Symbols and Valency

Element	Symbol	Valency
Hydrogen	H	1
Chlorine	Cl	1
Sodium	Na	1
Magnesium	Mg	2
Sulphur	S	2, 4

Element	Symbol	Valency
Oxygen	O	2
Nitrogen	N	3
Aluminium	Al	3
Iron	Fe	2, 3
Carbon	C	4

A bundle of atoms instead of single atoms takes part to form compounds. They cannot stay as separate atoms. These bundle of atoms with charge are called Radicals. For

example: SO_4^{2-}, CO_3^{2-}, NO_3^-, NH_4^+. Some examples of Radicals are: Nitrate (NO_3^-) and (Ammonium) NH_4^+ both with valency 1, Valency of Carbonate (CO_3^{2-}) is 2 and Phosphate (PO_4^{3-}) is 3.

8.1.1 RULES OF WRITING CHEMICAL FORMULA USING VALENCY

1. Molecular formulas give an idea about the number of atoms present in a compound. Firstly, the elements are represented by their individual Symbols. If the elements or radicals present in the compound have the same valency, then we don't need to write the valency in the formula. We just write the symbols of the elements together side by side. For example: CaO (Calcium Oxide), NH_4Cl (Ammonium Chloride) etc.

2. If the valencies of the two elements are divisible by a common number, then reduce their valencies finding the ratio. Then, the symbols of both the elements are written side and each is followed by the reduced valency of the other element. For example: in Carbon Dioxide, the valencies of Carbon (C) and Oxygen (O) are 4 and 2 respectively. Therefore, the formula for Carbon Dioxide is C_2O_4, but we divide both the valencies with 2 and write it as CO_2.

3. If the valencies of the containing elements or radicals are not divisible by a common number, for example if the valency of A is x and valency of B is y, and x and y are not divisible by a common number, then the formula of the compound formed by A and B will be A_yB_x. That means, the valency of B will be written as subscript on the right side of A and valency of A will be written next to B in the same way. For example—in Aluminium Oxide, the valencies of Aluminium and Oxygen are respectively 3 and 2, so the formula for this compound is Al_2O_3.

8.2 CHEMICAL EQUATION

During a chemical reaction, the bonds between the reactant molecules break down and form new bonds to create new matters. When we describe a chemical reaction, we use chemical equations to represent it.

A chemical reaction can be divided into two parts. One part contains the reactants and the other contains the new formed products. When writing a chemical equation, reactants are written on the left hand side of the chemical equation and the products formed during the chemical reaction is written on the right hand side. A one-way or two-way arrow is put in the middle to connect the reactants and the products sides. Following is an example:

$$A + B \longrightarrow C + D$$

Here, A and B are the reactants which undergoes chemical reaction to form products C and D. In a true chemical equation, the reactants and products are represented by their chemical formulas. Example:

$$\underset{\text{(Sulphur)}}{S} + \underset{\text{(Oxygen)}}{O_2} \longrightarrow \underset{\text{(Sulphur Dioxide)}}{SO_2}$$

No atom is destroyed or created in a chemical reaction, they are only rearranged. Therefore, the total number of atoms in the reactants before the chemical reaction is equal to the total number of atoms in the products formed after the chemical reaction. So, to summarize from the above discussions, chemical equation is the method of representing a chemical reaction in a short form by writing the reactants taking part in a chemical reaction and the products formed after it by using their symbols, formulas and certain mathematical notations. For example

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphuric Acid)}}{H_2SO_4} \longrightarrow \underset{\text{(Zinc Sulphate)}}{ZnSO_4} + \underset{\text{(Hydrogen)}}{H_2}$$

8.2.1 RULES OF WRITING CHEMICAL EQUATIONS

The rules of writing a chemical equation is described below:

1. The reactants are denoted by their chemical symbols or formulas and written on the left hand side of the arrow ($\longrightarrow$). Note that an arrow notation separates the reactants from the products. The new formed substances are also denoted by their symbols and formulas and written on the right hand side of the arrow.

2. If there are more than one reactants and products, an addition sign (+) is put between them.

3. Chemical equations also use equal sign (=) instead of arrow ($\longrightarrow$), but it is only used when the equation is balanced on both sides with regard to the number of molecules.

BALANCING CHEMICAL EQUATIONS

Balancing chemical equations means ensuring that the number of atoms in the reactants before the chemical reaction and the number of atoms in the products after the reactions is equal. Therefore, to balance the equation, we need to multiply the molecules on both

sides (reactants and products) of the equation to make sure the number of atoms of each element is the same on both sides.

For example, in the reaction between hydrogen (H_2) and oxygen (O_2) to produce water (H_2O), we can write the chemical equation according to the rules of chemical equations as follows:

$$H_2 + O_2 \longrightarrow H_2O$$

Notice here that the number of H and O atoms should have been equal before and after the reaction, which is not the case above. That is why, to balance the number of atoms, the number of H_2, O_2, H_2O molecules will be as follows:

$$2H_2 + O_2 = 2H_2O$$

In the above equation, the total number of Hydrogen and Oxygen atoms before and after the reaction is equal, that is, the equation is balanced.

8.3 CHEMICAL REACTION & CHEMICAL CHANGE

Chemical change refers to the process in which one or more substances undergo a chemical reaction to form new one or more substances. During a chemical change, the atoms and molecules of reactants rearrange themselves to produce new substances. Chemical changes often involve the exchange of energy; sometimes heat is released, and sometimes it is absorbed, resulting in a change in the temperature of the reactants and products. The properties of the reactants and products in a chemical change are usually different, and these changes are generally irreversible.

Chemical reactions can take various forms, such as, addition, combustion, substitution, and decomposition reactions.

8.3.1 Addition reaction

The chemical reaction where two or more reactants take part to create one product is called Addition reaction. The following example will give you an idea about Addition reactions.

In a laboratory under a controlled environment, when iron filings and sulfur powder are mixed together in a test tube and heated, two reactants (iron and sulfur)

combine to form the product Ferrous Sulfide. The substance obtained from the test tube is of a deep grayish color, and no trace of either yellow sulfur or iron filings is visible. This is because iron and sulfur have combined to produce an entirely different substance, Ferrous Sulfide (FeS).

$$\underset{\text{(Iron)}}{Fe} + \underset{\text{(Sulphur)}}{S} \longrightarrow \underset{\text{(Ferrous Sulphide)}}{FeS}$$

These type of chemical reactions where more than one substance react together to create one new product, are called Addition reactions. Let us look at another example. Zinc (Zn) and Sulphur (S) react together to produce Zinc Sulphide (ZnS). This is also an Addition reaction.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphur)}}{S} \longrightarrow \underset{\text{(Zinc Sulphide)}}{ZnS}$$

Both of the above Addition reactions show the production of a compound from more than one reactant elements. However, compounds can also act as reactants to undergo Addition reactions and produce a completely new compound. For example, Ammonia (NH_3) combine with Hydrogen Chloride (HCl) to produce Ammonium Chloride (NH_4Cl). The reaction is shown below:

$$\underset{\text{(Ammonia)}}{NH_3} + \underset{\text{(Hydrogen Chloride)}}{HCl} \longrightarrow \underset{\text{(Ammonium Chloride)}}{NH_4Cl}$$

8.3.2 combustion reaction

The reactions where any substance react with Oxygen to produce light and heat are called Combustion reactions. The presence of Oxygen is required for it to be a Combustion reaction and Oxygen acts as a reactant. We all have seen various Combustion reactions around us. Some examples of combustion reactions are lighting or burning of candles, gas burning in stove, burning of petrol in the engines of vehicles, etc.

Instead of candles, if you ever heat Sulphur, you'll see that first it melts; then we can see blue flames. When Sulphur (S) is heated, it reacts with the Oxygen (O_2) of the air to produce Sulphur Dioxide (SO_2) gas.

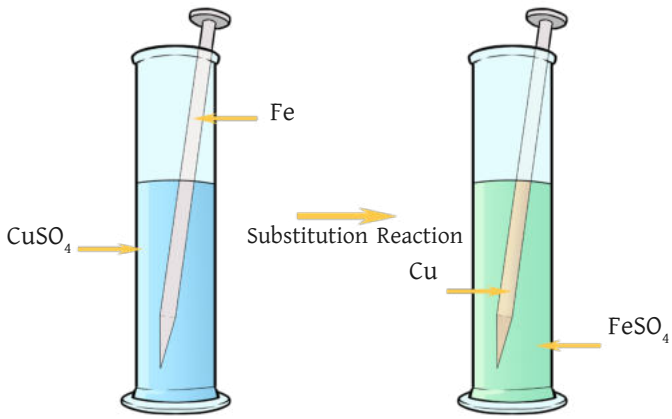
$$S + O_2 \longrightarrow SO_2$$

(Sulphur) (Oxygen) (Sulphur Dioxide)

Since Sulphur Dioxide (SO_2) gas is poisonous, this reaction is should never be done without a proper and safe laboratory condition.

8.3.3substitution reaction

The reactions where an element displaces another element from a compound and takes its place to produce a new compound are called Substitution reactions. The following simple but interesting experiment will help you understand Substitution reactions more clearly. To conduct this experiment, you will only need a little bit of copper sulfate ($CuSO_4$) to add to the other materials easily available around you.



Demonstration of the substitution of Iron by Copper

First, take a glass container and fill it with a small amount of water. Stir the water well and add the copper sulphate. Stir until you create a nice blue solution. Now, take a clean piece of iron (or iron nail) and carefully place it in the solution. You will observe a change in color at the submerged part, resembling the formation of rust. However, it is not rust; it is copper from the copper sulfate displacing the iron (Fe) from the iron piece due to its higher reactivity.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

(Iron) (Copper Sulphate) (Ferrous Sulphate) (Copper)

Since this reaction occurs slowly, if you wait for a few hours and occasionally shake the glass container to displace the rust forming on the iron nail, you will notice that copper (Cu) begins to accumulate at the bottom. That's not all; you will see that the blue copper sulfate ($CuSO_4$) solution has turned into a light green ferrous sulfate ($FeSO_4$) solution.

You can also use Zinc Sulphate ($ZnSO_4$) or Magnesium Sulphate ($MgSO_4$) in place of Copper Sulphate to do this experiment to demonstrate Substitution reactions.

8.3.4 decomposition reaction

Decomposition reaction is the opposite of Addition reaction. The reactions where a reactant breaks into one or more product elements or molecules are called Decomposition reactions. Following is a general example:

$$AB \longrightarrow A + B$$

Here, AB is a reactant. AB breaks into two products A and B. To understand Decomposition reactions more clearly, study the following experiment.

In a safe laboratory environment, if we heat a small piece of Limestone ($CaCO_3$) or calcium carbonate in a test tube, we will observe that calcium carbonate breaks down or decomposes to form Calcium Oxide (CaO) and Carbon Dioxide (CO_2) gas. The reaction is shown below:

$$\underset{\text{(Calcium Carbonate)}}{CaCO_3} \longrightarrow \underset{\text{(Calcium Oxide)}}{CaO} + \underset{\text{(Carbon Dioxide)}}{CO_2}$$

You can test whether the produced gas is Carbon Dioxide or not. If you collect the produced gas and pass it through clear lime water, you will observe that the lime water becomes cloudy. The clear lime water is Calcium Hydroxide ($Ca(OH)_2$), and it reacts with Carbon Dioxide (CO_2) to produce insoluble Calcium Carbonate, which is why the lime water turns milky white.

$$\underset{\text{(Carbon Dioxide)}}{CO_2} + \underset{\text{(Calcium Hydroxide)}}{Ca(OH)_2} \longrightarrow \underset{\text{(Calcium Carbonate)}}{CaCO_3} + \underset{\text{(Water)}}{H_2O}$$

So, we essentially get back the Calcium Carbonate that we initially decomposed!

8.4 TRANSFORMATION OF ENERGY IN CHEMICAL REACTIONS

There are different forms of energy, such as thermal energy, light energy, mechanical energy, potential energy, electrical energy, chemical energy, sound energy, and so on. You have learned that energy cannot be created or destroyed; it can only be transformed from one form of energy to another. Here are some examples of transformation of energy through chemical reactions:

Thermal Energy:

We most often observe energy transformation around us in the form of thermal energy through chemical reactions. Any combustion process is an example of this. For instance, when we light a candle or use a stove, heat energy is generated through a chemical reaction. Even in our bodies, heat energy is produced through chemical reactions, such as digestion and metabolism. In the case of baking soda and lemon juice, a chemical reaction takes place that absorbs heat, causing the mixture's temperature to decrease.

Light Energy:

Light energy is generated from thermal energy through chemical reactions. For example, in the flame of a candle, chemical reactions produce thermal energy, which then converts into light energy. But chemical reactions can also generate light energy without generating any thermal energy. The well-known example for this is fireflies, where luciferin, a chemical substance in their bodies, reacts with oxygen to produce light.

Electrical Energy:

We obtain electrical energy from chemical reactions in batteries. The combination of zinc, ammonium chloride, and manganese dioxide in dry cells creates electrical energy. In rechargeable lithium-ion batteries, the opposite reaction occurs when electricity is supplied to reverse the chemical reaction, storing electrical energy for later use.

Sound Energy:

We can make loud sounds by burning firecrackers or fireworks. Sound is produced here due to the rapid chemical reactions during the explosions that lead to the rapid expansion of gases, creating sound waves.

Chemical Potential Energy:

Chemical bonds store energy, and this energy can be released when these bonds break. One example is the adenosine triphosphate (ATP) molecule in living organisms, which stores energy and is known as the biological currency of energy.

From the above discussion, you can see that chemical energy can be transformed into various forms of energy, which we utilize in various fields of our lives, starting from industrial processes to everyday applications.

To give an example, the transformation of chemical energy into electrical energy using dry cells is discussed below.

8.4.1 electrolyte and electrolysis

Before we learn about dry cells, we have to have a basic idea about Electrolytes and Electrolysis. The substances that conduct electricity in their melted or solution state while simultaneously undergoes chemical reaction to transform into other substances are called Electrolyte and this process is called Electrolysis.

In the process of electrolysis, an electric current is used to break down ionic compounds into their constituent ions. As shown in the diagram, two electrodes are immersed in an electrolyte solution. When a DC electric current flows between the electrodes, the cations of the electrolyte migrate to the cathode, while the anions migrate to the anode. By adding a small amount of acid or salt to pure water and passing an electric current through it, we can perform electrolysis to separate hydrogen and oxygen. When sodium chloride solution is subjected to electrolysis, it is possible to obtain sodium metal and chlorine gas from it.

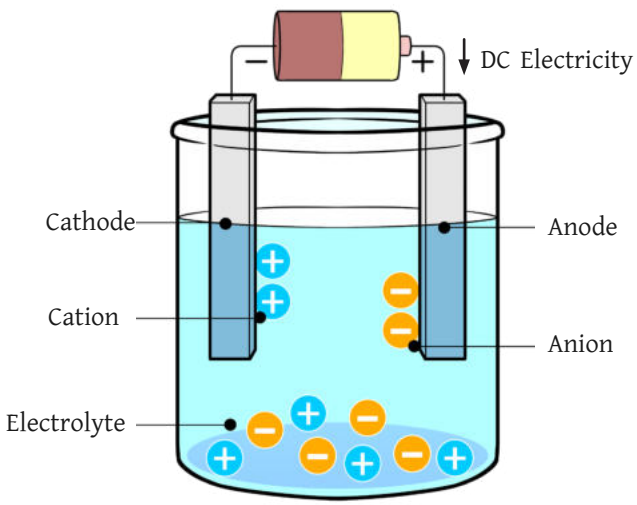
Dry cell

All of you have used batteries at some point, whether it's in a flashlight, a toy, a remote control, or elsewhere. In these batteries, there are dry cells consisting of an anode, a cathode, and an electrolyte in between. The anode functions as a zinc metal casing, and the cathode is surrounded by a paste of manganese dioxide. Ammonium chloride (NH_4Cl) serves as the electrolyte in the middle of the anode and cathode. Ammonium chloride acts as an ionic conductor since it contains negatively charged ions (Cl^-) and positively charged ions (Zn^{2+}, NH_4^+).

Function of the dry cell:

In Dry Cells, a chemical reaction occurs between ammonium chloride, zinc, and manganese dioxide. As a result, there is a voltage difference of 1.5 volts between the two ends of the cell. This voltage can be used to power an electrical circuit when connected at both ends.

The cell described above is also known as a zinc-carbon cell. It's worth noting that instead of



The Process of Electrloysis

ammonium chloride, if potassium hydroxide (KOH) is used as the electrolyte, then this cell is referred to as an alkaline cell. Alkaline cells, which often use a zinc-carbon cell like this one, are much more effective.

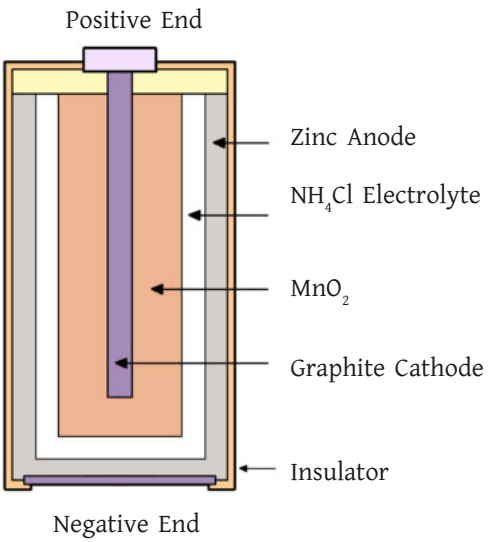


Figure: Dry Cell

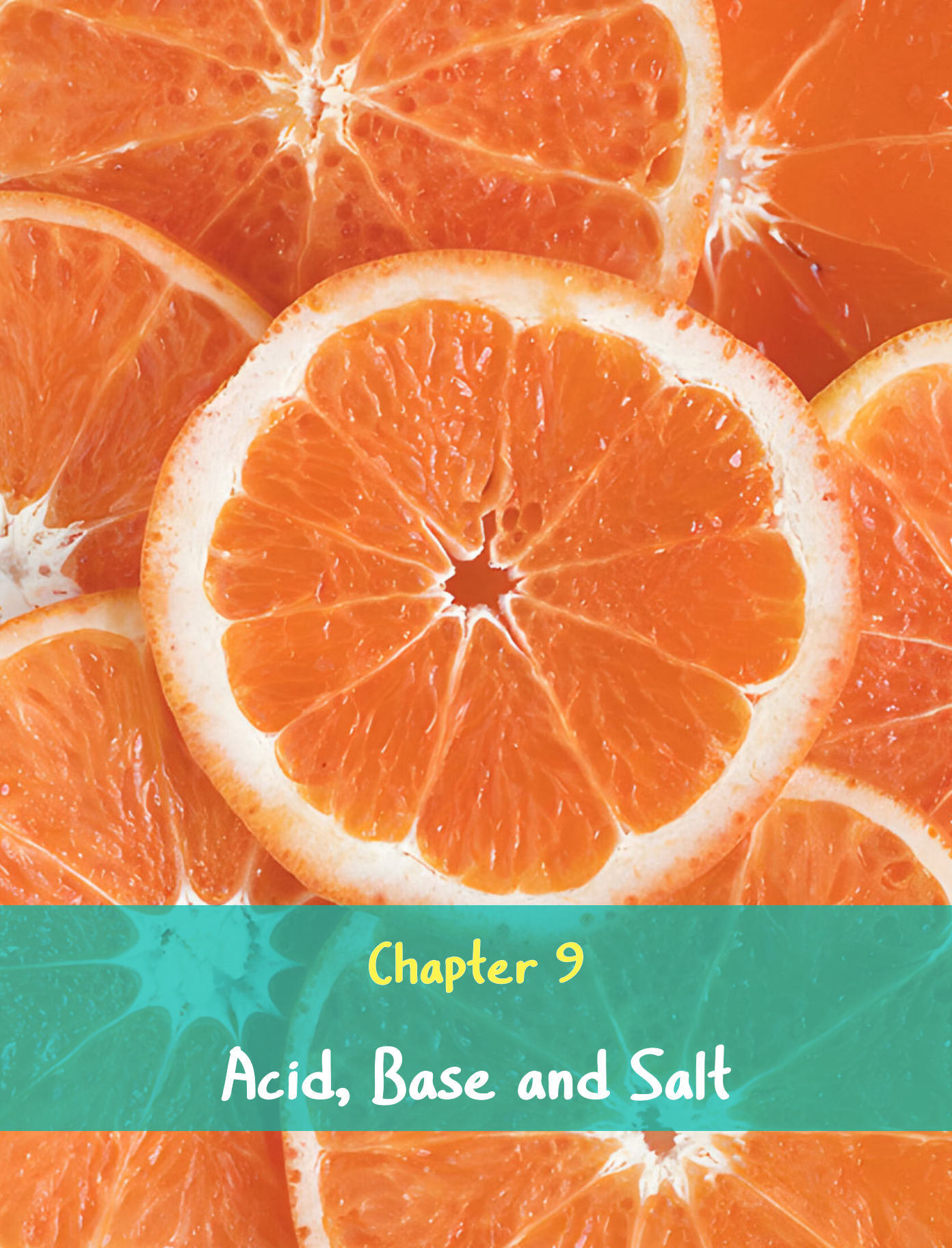
8.5 CONSERVATION OF MASS DURING CHEMICAL REACTIONS

No atom is created or destroyed during a chemical reaction. The atoms in the reactants only rearrange themselves to form new products. Therefore, in a closed condition where nothing can get in or out, there is no change in total mass of the atoms before and after a chemical reaction. This is known as the Law of conservation of mass.

Since no mass is created or destroyed during a chemical reaction, so the sum total of the mass of the reactants before the reaction and that of the products after it remains unchanged. Look at the following reaction for example:

$$\underset{100\ g}{CaCO_3} \longrightarrow \underset{56\ g}{CaO} + \underset{44g}{CO_2}$$

Here, the sum total of the mass of the reactants (100 g) = the sum total of the mass of the products [(56 + 44) g = 100 g]. There, there have been no change of mass during the above reaction.



Chapter 9

Acid, Base and Salt

Chapter 9 Acid, Base and Salt

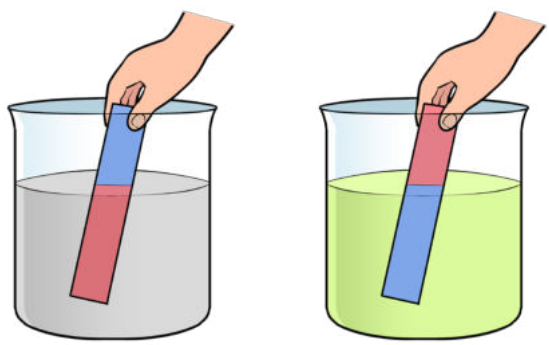
This chapter deals with the following topics:

- ☑ Acid, base, and indicator
- ☑ Reactions of acid and base, salt
- ☑ Important properties of acid and base
- ☑ Uses of acid and base
- ☑ Identification of acid and base

Acid, base, and salt are important things we use in our daily life. Some of these acid, base, and salt can be found naturally. For instance, lemon juice and oranges have citric acid, tamarind has tartaric acid, and milk has malic acid. Similarly, limewater is a type of base. Sea water has sodium chloride, which is purified and used as regular table salt. These acid, base, and salt have different chemical properties. That's why they are used differently based on their characteristics or properties.

9.1 Acid

You must have heard the name acid. Acid is a substance whose aqueous solution tastes sour, can make blue litmus paper turn red, and can neutralize bases. Litmus paper is a special kind of paper that is made by mixing dyes from a plant called lichen. Litmus papers are used to test whether a solution is acidic or basic. Acidic solutions make blue litmus paper turn red and basic solutions turn red litmus paper blue.Lemon juice has citric acid in it. If you have a red and a blue.litmus paper, then you can see that no chemical reaction will take place if the red litmus paper is dipped into the lemon juice. As a result,



Acid (Blue litmus paper has turned red) Base (Red litmus paper has turned blue)

Fig.: Change of the colour of a litmus paper in acidic or basic

the colour of the paper will not change. On the other hand, when the blue litmus paper is dipped into the lemon juice, the citric acid in the lemon juice reacts with it and turns the paper red. You already know that acidic solutions make blue litmus paper turn red. Just like lemon juice, other fruits like amla, carissa carandas, star fruit, lime (lemon), etc. have a sour taste because they also contain various types of acids. Now you can try using litmus papers with these fruits, such as amla or guava, instead of lemon juice, and observe how the paper's colour changes.

The table beside shows the formulae of some acids along with their names. You will get a similarity among all the acids mentioned in the table- all these acids have one or more hydrogen atom (H) and each of them can produce hydrogen ion (H^+) in water (H_2O). Therefore, we can say, acid is such a chemical substance which contains one or more hydrogen atoms and they produce hydrogen ion (H^+) in water.

Names and formulae of some acids

Name of acid	Formula
Vinegar or acetic acid	CH_3COOH
Oxalic acid	HCOO-COOH
Sulphuric acid	H_2SO_4
Nitric acid	HNO_3
Hydrochloric acid	HCl

As an example, you may observe the two chemical formulae of Hydrochloric acid (HCl) and aceticacid (CH_3COOH) in water (H_2O).

$$HCl \xrightarrow{H_2O} H^+ + Cl^-$$

$$CH_3COOH \xrightarrow{H_2O} H^+ + CH_3COO^-$$

These two acids in contact with water produce hydrogen ion. However, if there is a hydrogen atom in the substance, it will necessarily not an acid. You must have heard the name of methane gas. In our country, all the natural gas we have is methane. Its symbol is CH_4. methane has four hydrogen atoms but it is not an acid. Because it doesn't produce a hydrogen ion (H^+) in water.

9.2 Base

Base is a substance whose aqueous solution has a bitter taste, turns red litmus paper blue, and can neutralize acids.

Limewater is a type of base, which contains hydroxide ($Ca(OH)_2$). If you have a red and a blue litmus paper, then you can do an experiment. If you dip the blue litmus paper into the lime water, no chemical reaction will take place. As a result, the colour of the paper will not change. On the other hand, if the red litmus paper is dipped into the limewater, the calcium hydroxide in the limewater reacts with it and turns the paper blue.

Here, chemicals such as calcium hydroxide ($Ca(OH)_2$) in limewater that turn red litmus paper blue are also sometimes called alkalis. There are some alkalis that can dissolve in water (such as, NaOH, NH_4OH, $Ca(OH)_2$). Again there are some alkalis that cannot dissolve in water (such as, aluminium hydroxide ($Al(OH)_3$). The alkalis that do not dissolve in water are called bases. Therefore, sodium hydroxide (NaOH), aluminium hydroxide ($Al(OH)_3$) are alkali-like bases. On the other hand, aluminium hydroxide ($Al(OH)_3$) is an alkali. But since it does not dissolve in water, it is not a base though it is an alkali. Therefore, it can be said that **"all bases are alkalis but not all alkalis are bases".**

Alkalis are chemicals that contain oxygen (O) and hydrogen (H) atoms. They can form hydroxyl ions (OH^-) in water. Example:

$$NaOH \xrightarrow{H_2O} Na^+ + OH^-$$

$$NH_4OH \xrightarrow{H_2O} NH_4^+ + OH^-$$

$$Ca(OH)_2 \xrightarrow{H_2O} Ca^{2+} + 2OH^-$$

Here, sodium hydroxide (NaOH), ammonium hydroxide (NH_4OH) and calcium hydroxide ($Ca(OH)_2$) contain oxygen (O) and hydrogen (H) atoms and they have formed hydroxyl ions (OH^-) in water (H_2O). Therefore, they are alkalis.

However, there are some other chemical substances like calcium oxide (CaO) or ammonia (NH_3) that don't contain oxygen and hydrogen atoms. But they can still produce OH^- ions in water. That's why they are also called alkalis. Two reactions of calcium oxide (CaO) and ammonia (NH_3) in water are shown:

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$NH_3 + H_2O \longrightarrow NH_4OH$$

You all know that soap feels slippery to the touch. This is because soap contains base. So, a characteristic of both base and alkaline is that they are slippery and they also have a bitter taste.

Caution: When discussing the characteristics of acids and alkalis, their sour and bitter tastes are mentioned, respectively. But never try to test the taste of any acid or base other than familiar fruits such as oranges or lemons.

9.3 salt

Whenever we talk about salt, we refer to sodium chloride (NaCl) or the salt that we use in our food. But the word salt is used more widely in science. Salt is an ionic compound where a positively charged ion (cation) and a negatively charged ion (anion) are connected. Because of the neutralisation reaction among different types of acids and bases, different types of salts and water are produced at the same time. So, salt is a neutral substance whose aqueous solution does not change the colour of a litmus paper. Sodium chloride (NaCl) is an example of the commonest salt. Besides being used in food, salt is used for various purposes in our daily life. You might know that sea water also contains a lot of sodium chloride (NaCl) and that's why the sea water has a salty taste.

Following reaction between acid and base shows the formation of salt:

$$\underset{\text{(acid)}}{HCl} + \underset{\text{(base)}}{NaOH} \longrightarrow \underset{\text{(salt)}}{NaCl} + \underset{\text{(water)}}{H_2O}$$

9.4 Use of acid and alkali

We use acid and substances like base or alkali for some important purposes in our daily life. Uses of these substances are discussed below:

9.4.1 Use of acid

1) Vinegar or acetic acid is used to preserve food. Acetic acid is used as a solvent for ink and dye.

2) Acids found in fruits or vegetables are called organic acids. For example, citric acid

is found in lemons, oranges and other citrus fruits. In food industries, citric acid is used to increase the taste of certain food items like carbonated drinks. Citric acid is also used to kill harmful germs. Some of the organic acids are essential for human body. For example, ascorbic acid, which we call Vitamin C. Deficiency of Vitamin C causes scurvy in human body.

3) We use different kinds of acids in our everyday life and industries. The cleaning products we use to clean toilets contain acids. Goldsmiths use nitric acid (HNO_3) in making gold jewellery. Besides, nitric acid is used as the main component in making fertilizer by producing ammonium nitrate. HNO_3 is used to extract valuable metals like gold from mines and is even used in rocket fuel.

Besides nitric acid, another commonly used acid is sulfuric acid (H_2SO_4). For example, batteries used in IPS, cars, solar power generation etc. contain H_2SO_4. In addition, significant quantities of sulfuric acid are also used in manufacturing detergents, different dyes, pesticides, paper, and explosives. The amount of sulfuric acid a country uses is often an indicator of how industrialized that country is.

First aid for acid accident:

If our skin ever comes into contact with acid, we have to immediately clear all the acids with a continuous flow of water on the affected area for at least 20 minutes. If our cloths come into contact with acid, the clothes should be removed from the body without directly touching them. Since acid can cause severe burns, the affected person should immediately be taken to hospital for proper treatment. We all should always be aware of the use of acid and make others ware of it.

4) Our stomach needs acid to digest the food we eat, and this is done by hydrochloric acid (HCl). Besides, HCl is also used in steelmaking industries, medicine and leather industry. Moreover, phosphoric acid (H_3PO_4) is a main component in many soft drinks.

Some acids are made from various minerals found in nature. They are called mineral acids. Hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid, etc. are examples of mineral acids. These acids are not suitable for consumption and can be harmful to human bodies. If these acids come in contact with our skin, they can cause serious damage to the skin.

9.4.2 Use of base or alkali

1) We are familiar with bleaching powder. This widely used powder is made through

the reaction of dry calcium hydroxide ($Ca(OH)_2$) and chlorine gas (Cl_2). You know that this calcium hydroxide is a base or alkali. Additionally, a light solution of calcium hydroxide, known as lime water, is used for whitewash purposes.

Furthermore, a paste made of calcium hydroxide ($Ca(OH)_2$) and water, called milk of lime, is used to control insects.

2) Sodium hydroxide (NaOH) is used in soap and paper production. It is also used in the production of rayon.

3) When we experience acidity in our stomach, we take a type of medicine called antacid. What exactly is this antacid? Antacid is basically magnesium hydroxide ($Mg(OH)_2$) which is available in both suspension and tablet forms. The suspension of magnesium hydroxide is known as milk of magnesia. Sometimes, antacid may also contain aluminium hydroxide ($Al(OH)_3$).

4) Ammonium hydroxide (NH_4OH) is an essential reagent in the laboratory.

9.5 Some important chemical properties of acids and bases

Some properties of acid and base are presented througt chemical reaction:

9.5.1 Reaction of acid with metal:

Metals such as zinc (Zn) react with sulfuric acid (H_2SO_4) and produce salts and hydrogen gas (H_2). The reaction is as follows:

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

Almost all acids, like sulfuric acid, react with metals and produce hydrogen gas. Another reaction between metal and acid is shown below:

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow$$

9.5.2 Reaction of base with acid:

H_2SO_4 is an acid and $Ca(OH)_2$ is a base. These two react and produce calcium sulphate ($CaSO_4$) and water. The reaction is shown below:

$$\underset{\text{(base)}}{Ca(OH)_2} + \underset{\text{(acid)}}{H_2SO_4} \longrightarrow \underset{\text{(salt)}}{CaSO_4} + \underset{\text{(water)}}{H_2O}$$

The $CaSO_4$ produced here is a salt. So, it can be said that salt is the main element produced in the reaction of acid and base. Another reaction of acid and base is given below:

$$\underset{\text{(base)}}{NaOH} + \underset{\text{(acid)}}{HCl} \longrightarrow \underset{\text{(salt)}}{NaCl} + \underset{\text{(water)}}{H_2O}$$

9.5.3 Reaction of acid with carbonate:

Almost all acids react with carbonates and produce CO_2 gas. The reaction of hydrochloric acid (HCl) with limestone ($CaCO_3$) is shown below:

$$CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO_2\uparrow$$

CO_2 produced by utilizing this property of acids is sometimes used to extinguish fire.

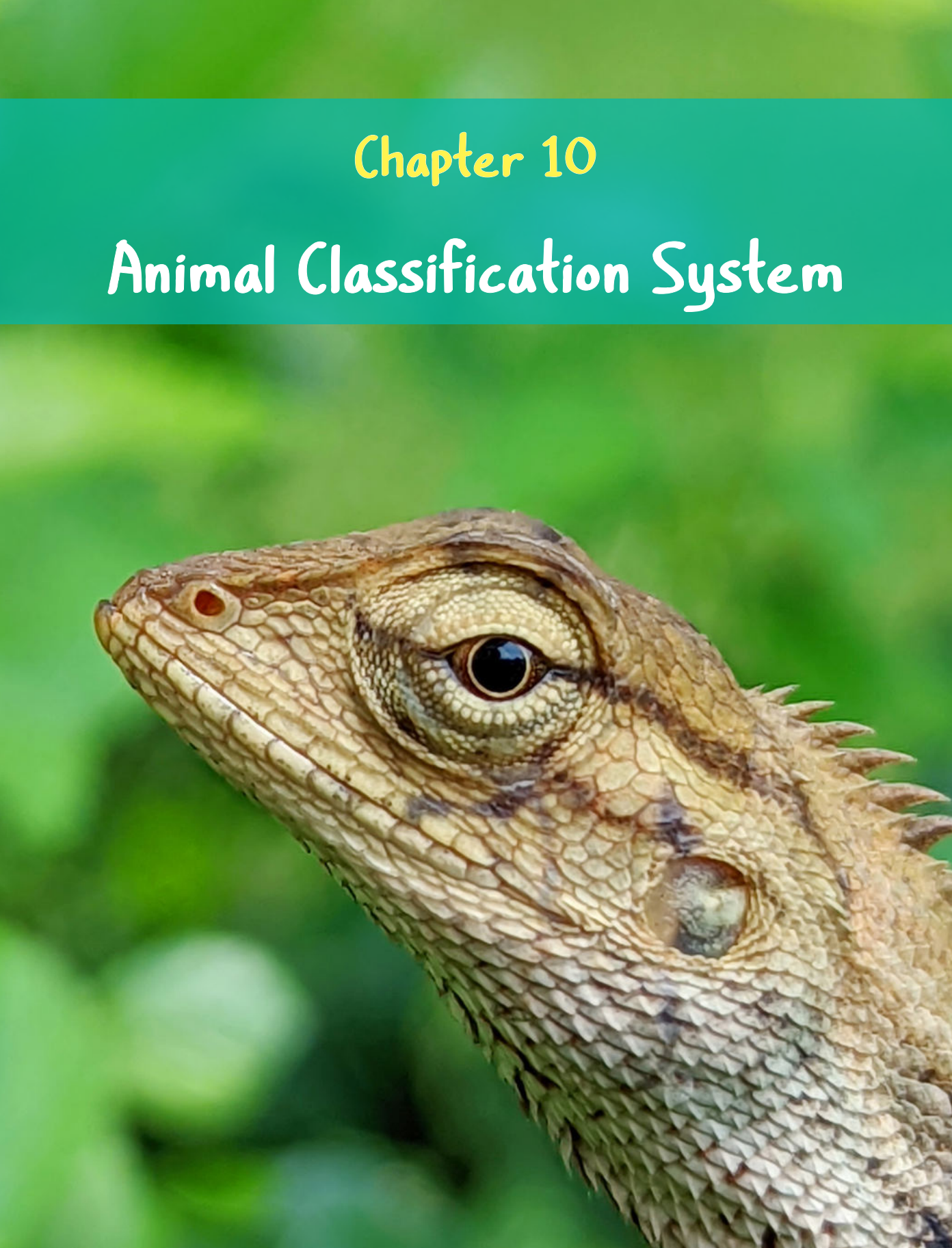
The reaction of baking soda ($NaHCO_3$) and HCl is shown below.

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$$

Do by yourself: Many of the above reactions are shown without equalization. Can you equalize them?

Chapter 10

Animal Classification System



Chapter 10 Animal Classification System

This chapter deals with the following topics:

- ☑ Classification of Animal World :
- ☑ The basis of the classification of plant kingdom
- ☑ The basis of animal classification
- ☑ Taxonomic characteristics of animals for identification and their examples
- ☑ Insects
- ☑ Mammals
- ☑ Human's position in the animal world

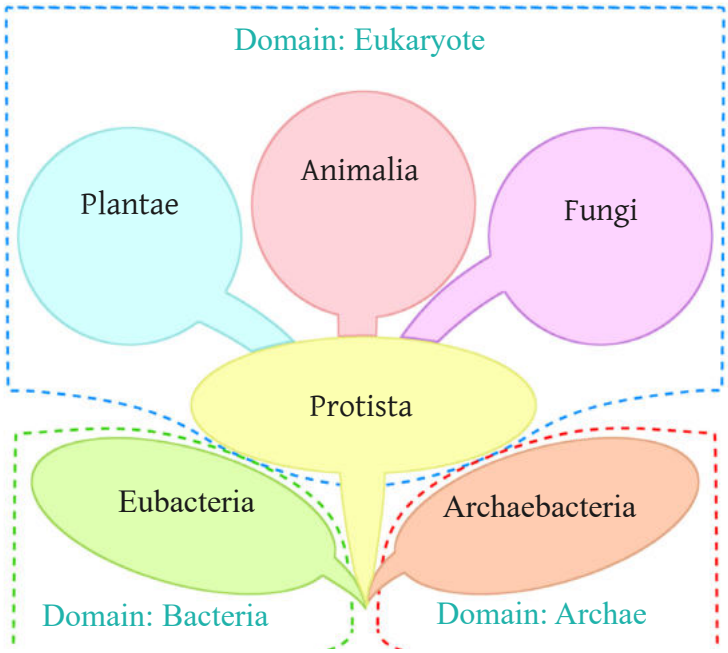
10.1 Classification of Organisms:

From the very birth of the Earth, there has been diversity in the biosphere or the living world. At present, there are approximately ८७ lakh species of organisms living in the world. Not only that, new organisms are also being discovered almost every day. The diversity of the biosphere is due to the different characteristics of the various types of organisms. All organisms depend on each other for their survival, so the contribution of this living world to maintain the balance of the environment is immense. These organisms have a variety of differences, their structures are different, their habitats are different, some are beneficial and some are harmful. Therefore, it is necessary to have a comprehensive idea about the classification of organisms in the biosphere.

Scientists have been trying to classify this vast number of organisms for hundreds of years. With the help of classification, all the species of the world can be known easily in a scientific way, with less effort in less time. Classification is essential for identifying new species. Not only that, it provides various information and data on the inter-relationships among different organisms, and gives the idea about the gradual changes that have occurred or are occurring among them.

Once upon a time, it was believed that the living organisms on Earth are divided into two kingdoms: plants and animals. However, with the scientific advancements, scientists gradually realized that this classification of living organisms into just plants

and animals was not sufficient. For example, fungi are quite different from plants. They do not have chlorophyll and cannot produce their own food like plants. So, fungi are included in a separate kingdom. The discovery of the microscope led to the identification of a vast world of microorganisms, and scientists could learn about the structure of cells. Therefore, a separate kingdom is required for unicellular or single-celled organisms. But even among unicellular organisms, there are two clear divisions based on the structure of the cell: prokaryote (unorganized nucleus in the cell) and eukaryote (organized nucleus in the cell). Therefore, two different kingdoms are classified: Monera for prokaryote unicellular organisms and Protista for eukaryote unicellular organisms. With further advancements in science, scientists discovered that there are two distinct divisions called Archaebacteria and Eubacteria among prokaryote unicellular animals of the Monera kingdom, and they cannot be included in one kingdom. Consequently, at present, instead of Monera, Archaebacteria and Eubacteria are referred to as the two kingdoms. Therefore, if the living world is divided into six kingdoms: animals, plants, fungi, Protista, eubacteria and archaebacteria, it is possible to classify all organisms into specific categories.



Classification of organisms into kingdoms and domains

The following characteristics are considered for the classification of living organisms.

1) Number of cells (unicellular or multicellular)

2) Type of cells (prokaryotic or eukaryotic)

3) Type of nutrition (autotrophic or heterotrophic)

At the same time, genetics continued progressing and organisms are divided into

three domains: Eukarya, Bacteria, and Archaea, in a completely different way from the genetic structure of organisms. The related picture shows how the six kingdoms have evolved into three domains.

A brief description of important characteristics the six kingdoms is presented below. It is worth mentioning that the living world is so diverse that many exceptions can be found among the characteristics mentioned above. For example, there are mammals called platypus that lay eggs, ghost plants that have no chloroplasts, protists called kelp that cover large areas, sea slugs that can photosynthesize, etc.

Animal:

This is the largest kingdom, with about 1 million species. They are multicellular, eukaryotic, motile, heterotrophic or parasitic, and reproduce sexually, contributing to population growth.

Plant:

There are about 2.5 lakh species of plants. They are also multicellular, eukaryotic, and autotrophic. Plant cells have chloroplasts and synthesize their own food through photosynthesis, and provide food for other animals in the biosphere. Apart from that, plants create oxygen and keep the biosphere alive.

Fungi:

There are about 1.5 lakh species of fungi. They are generally multicellular, eukaryotic, and heterotrophic or parasitic organisms. They create nutrient-rich food from perishable organic matter and play a vital role in maintaining the ecosystem.

Protista:

Most Protistans are unicellular, eukaryotic, and heterotrophic. Protistans can resemble animals, plants, or fungi in some aspects.

Eubacteria:

Eubacteria are prokaryotic, unicellular, and heterotrophic (parasitic). They reproduce through binary fission or amitosis, an asexual process. They can infect humans.

Archaebacteria:

Archaebacteria are prokaryotic, unicellular, and ancient bacteria. Archaebacteria have been found in adverse environments such as hot springs, deep-sea hydrothermal vents, and hypersaline places. They cannot infect humans. Because they are much different from bacteria, they are often simply called Archaea.

You all know that there is another large world of acellular (noncellular) microorganisms

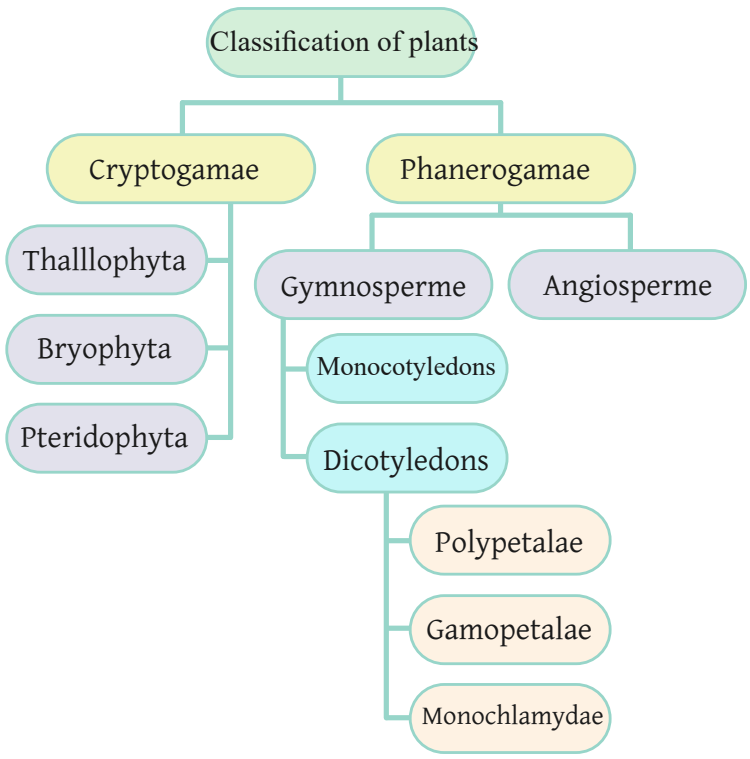
in addition to the six kingdoms mentioned above. An example of such microorganism, which is outside the living world, and between living and non-living matter, is the virus. In the previous class, you learnt in detail about bacteria, fungi, and Protista. In this chapter you will learn about the plant and animal kingdoms.

10.2 The Basis of the Classification of Plant Kingdom

An attempt has been made to classify the plant kingdom based on various characteristics of plants. For example, various species of plants are seen around us, whose life span is one year. Again, perennial plants are also seen alongside. Some plants bear flowers, while many are flowerless. Again, there is a lot of variation in shape and size. There are various types of plants based on food preparation and food intake. For this reason, two English botanists named George Bentham (1800-1884) and Sir Joseph Dalton Hooker (1817-1911) proposed a classification system based on different characteristics of plants. This natural system of classification of plants was first published in their book Genera Plantarum written in Latin and published in three volumes. The classification of plants proposed by Bentham and Hooker is described here. They have divided the entire plant kingdom into two sub-kingdoms namely Cryptogamiae or non-flowering plants and Phanerogamae or flowering plants.

10.2.1 Cryptogamae

Plants that never produce flowers are known as non-flowering plants or Cryptogamae. They reproduce by spores. Non-flowering plants are again divided into three groups in the natural system of classification:

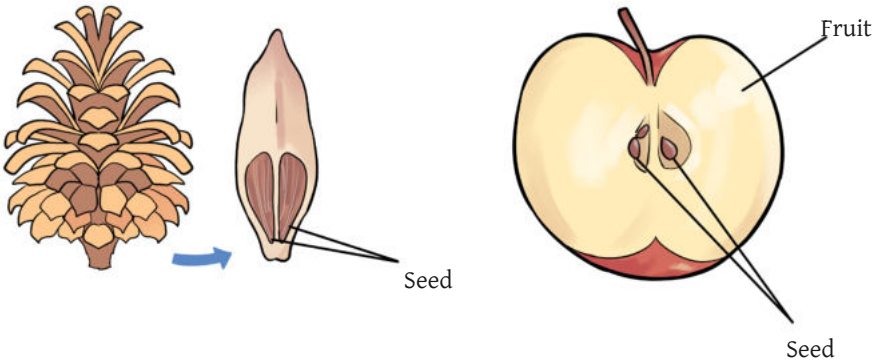


1) Thallophyta
2) Bryophyta
3) Ptreidophyta

1) Thallophyta:

All plants whose body cannot be divided into roots, stems, and leaves are included in this category. They do not

have a vascular system. The reproductive organs are usually unicellular. There are about 1 lakh 10 thousand species of Thallophyta.



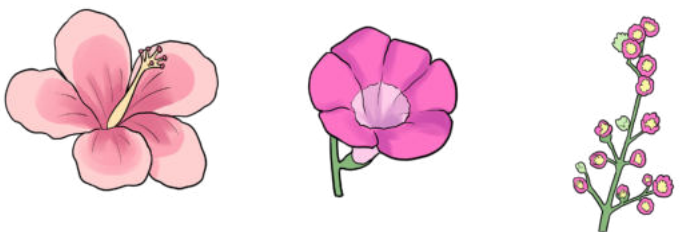
Gymnospermae and Angiospermae

2 । **Bryophyta:** Plants in this order have soft stems and leaves. Instead of roots, their bodies have filaments like rhizoids, through which they absorb essential water and mineral salts from the soil. No vascular system is seen in their body. There are about 23,000 species of Bryophyta

3 । **Pteridophyte:** The body of pteridophytes can be divided into roots, stems and leaves. There is a vascular system in their body. The total number of pteridophytes is ten thousand.

10.2.2 Phanerogamae

Plants that produce flowers (and seeds) are included in this sub-kingdom. They reproduce through seeds. Pine, mango, java plum, jackfruit etc. are examples of seed plants. This sub-kingdom is divided into two categories:



Polypetalae, Gamopetalae, Monochlamydae

1) Gymnospermae
2) Angiospermae

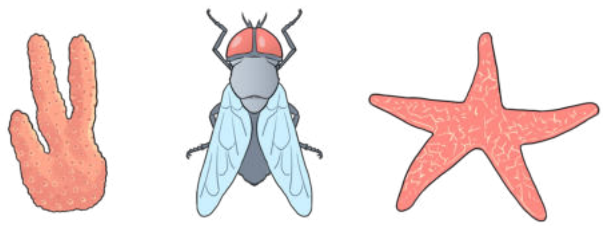
1) Gymnospermae : The plants of this category do not have ovary in its gynoecium. So, they do not produce fruits. Since they do not have ovary, their seeds remain naked. That is why, they are called gymnosperms. Cycas, Pinus etc. are examples of Gymnospermae.

2) Angiospermae: These plants have ovary in their flowers, so they produce fruits, and the seeds are enclosed within the fruits. Angiosperms can be divided into two classes based on the number of cotyledons in the seed:

a) Monocotyledons
b) Dicotyledons

a) Monocotyledons: Plants that have only one cotyledon are called monocotyledons. Their leaves have parallel venation and the roots are clustered. The vascular tissues in the stem are sparsely arranged without cambium. The number of species of monocotyledonous plants is more than 18000. Rice, wheat, banana, taro, coconut etc. are some examples of monocotyledons.

b) Dicotyledons: Plants that have two cotyledons in their seeds are dicotyledons. The leaves of dicotyledonous plants are usually reticulate venation, and the root form the main root system. The trunk of these plants consists of bundles of vascular tissue with cambium and arranged in circular form. Examples of dicotyledonous plants are jackfruit, litchi, rye mustard, dhutura etc. The number of species of dicotyledonous plants is about 80 thousand. Based on the presence, absence and attachment of petals, this category is divided into three subcategories-



Asymmetric sponge, bilaterally symmetrical fly, and starfish with asymmetric symmetry.

a) Polypetalae
b) Gamopetalae
c) Monochlamydae

a) Polypetalae: The flower petals of such plants are separate, or not connected. For example: mustard.
b) Gamopetalae: Such plants have flower petals joined together, such as dhutura.
c) Monochlamydae: All these plants do not have petals in their flowers. For example: jackfruit.

It is to be noted here that with the advancement of modern science and a clearer understanding of the biochemical composition of plants, the work of classifying new types of plants in combination with genetics and evolution has begun.

10.3 Basis of Animal Classification

Animals belongs to a large kingdom, and we try to divide them into different phyla based on various characteristics. Over billions of years, the characteristics of Earth's fauna have evolved in many ways.Over time, new traits have emerged, and these animals have adapted themselves in different ways to adapt to different environments. As a result, the incredibly diverse fauna we see today is extremely difficult to divide into a handful of phyla. For this reason, there is disagreement among scientists in many areas about the classification of animals.

The Swedish scientist Carolus Linnaeus (1707-1798) was the first to classify animals in a scientific and systematic way. He first introduced binomial nomenclature in the tenth edition of his book 'Systema Naturae'. Hence, he is called the father of taxonomy despite many changes in the taxonomic system or classification system later on.

All the animals identified so far in the world have been divided into nine major phyla based on some very specific characteristics. The characteristics based on which animals are classified are called taxonomic characteristics. First let's know a little about these features.

Some of the major taxonomic characteristics are explained below:

1. Cell Arrangement

According to the structure of different animals, they can be distinguished. By observing the structure of relatively primitive and simple multicellular organisms, such as sponges, we can see that their physiological functions are carried out at the cellular level. This means that cells are unorganized and perform their work separately. On the contrary, in the case of more complex animals, such as jellyfish, cells join together as tissues and participate in various physiological functions. In more complex animals, multiple tissues combine to form organs to perform specific tasks. In the case of humans or other vertebrates, these tissues are not only coordinated to form organs, but multiple organs are combined together to form a single system. This again performs a specific function in an orderly manner.

2. Body Symmetry

Based on body symmetry, animals can be distinguished. Some animals are totally asymmetric, such as sponge. It is not possible to divide their body into multiple identical parts. Again, it is possible to divide a cockroach, a bird or a human being into two exactly the same longitudinal shape. These animals are bilaterally symmetrical. Moreover, there are several animals such as starfish, jellyfish etc. whose bodies can be

divided into four, five or more identical parts. Their symmetry type is radial symmetry.

3. Body Cavity or Coelom

It is very important whether or not there is a body cavity made up of special parts in the animal body, and if so, how it is structured. Based on this, different animals are classified. This special body cavity has many roles in the animal body. In these cavities or coeloms, according to the type of work, various internal organs of the body (especially the organs of the digestive system) are grouped together. As a result, these organs are able to function in a coordinated way. Since the organs are immersed in a kind of liquid inside this body cavity, they are also protected from external pressure or shock. Simple organisms such as- corals or tapeworms do not have well-developed body cavities. On the other hand, complex organisms such as- humans and all vertebrates have well-developed body cavities.

4. Presence of Body Segmentation

The body of some animals is divided into several segments. For example, the body of an insect is divided into three parts, but the body of a spider is divided into two parts. Again, the same organ can be repeated successively. It is also considered as an important characteristic in the classification of animals.

5. Type of Skeletal System

While classifying, it is also an important consideration whether or not an animal has a skeleton, and if so, what type it is. Again, some animals have a well-developed skeletal system inside their bodies, such as- all vertebrates, including humans. Moreover, some animals do not have such a skeleton inside their bodies, but exoskeleton can be seen outside their bodies, such as- snails or crabs. Even, there are also exceptional examples like turtles which have both endoskeleton and exoskeleton.

Apart from the characteristics mentioned above, digestive system, circulatory system, mode of reproduction- etc. are also considered as important features while classifying animals.

It has been mentioned earlier, based on different characteristics, all the animals of kingdom Animalia are divided into nine main phyla. Animals in the first eight of these nine phyla are invertebrates and animals in the last phylum are usually vertebrates. Now let's know very briefly about the animals of these nine phyla.

Phylum-1: Porifera

Parifera animals can be said to be the simplest and most primitive members of the

animal kingdom. The most familiar members of these are sponges. These animals originate from marine environments, and are found in all oceans of the world and in some freshwater bodies. Though they are multicellular, their structure is very simple. Their body cells are isolated; they are unable to organize to form specific tissues or function as organs.

Porus means 'pore' and ferre means 'to bear'. These two words are combined to form the word Porifera. The animals of this phylum have numerous pores and canals, through which water continuously flows through their bodies. And through this flow, they receive food particles and oxygen from water and discharge waste from the body. The small pores in the body wall that allow water to enter are called Ostia. The inner chamber is surrounded by special cells called choanocytes with fine hair-like flagella. The choanocytes continuously move their flagella to create a flow of water in and out through pores at the top. During this process, the choanocytes take food from the water.

The major characteristics of this phylum are:

Structure and cellular arrangement: Though multicellular, the cells are not organized. So they do not have specific tissues or organs. That's why, the metabolic activities of animals of this phylum are done at the cellular level.

Sponge

Body symmetry: Asymmetric

Coelom: Absent

Presence of body segmentation: Absent

Type of skeletal system: Endoskeleton is present.

Other characteristics: We usually think that animals are capable of moving. But, almost all animals of the Porifera phylum lose their ability to move before they reach adulthood. Although they are motile in larval stage, they are permanently attached to the hard bottom of the sea in the adult stage.

Phylum-2: Cnidaria

The animals of the phylum Cnidaria are more complex than the animals of the phylum Porifera. The cells of these animals can form tissues, but they also do not have specific

organs. Inside the body there is a large cavity called the coelenteron, where food is digested and transported. (However, this cavity is not like the body cavity that you know as the coelom.) There is no separate digestive organ inside the coelenteron, but after the food reaches this cavity, the nutrients are absorbed from it with the help of the cells of its wall. Although there is only one mouth opening (মুখছদ্র), animals of this phylum have no separate anus. Usually there are trunk-like tentacles around the mouth to catch prey.

Jellyfish

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: Though tissues are composed of multiple cells, they do not have specific organs to perform specific functions.

Body symmetry: : Radial symmetry is found.

Coelom: Absent.

Presence of body segmentation: Absent.

Type of skeletal system: There is no strong skeleton system made of bones. However, the cavity called the coelenteron is filled with water which provides firmness to the body.

Other characteristics: However, the main characteristic of the animals of the phylum Cnidaria is that they have cells called Cnidoblast in their bodies, with the help of which they can all hunt or defend themselves by throwing poisonous stings or thorns. Hence the name of this phylum comes from the Greek word Knide meaning hairy and aria meaning connected. Among the animals of this phylum are—jellyfish, coral, hydra etc.

Phylum3-: Platyhelminthes

Although the name Platyhelminthes sounds strange, the animals of this phylum are not very unfamiliar to us. Flatworms or tapeworms are animals of this phylum. So, the name Platyhelminthes has also come from Greek 'platy' and 'helminthes' meaning 'flat' and 'worm' respectively. Although their structure is much simpler than that of vertebrates, they are somewhat more complex than those of the previous two phyla,

Porifera and Annelida. These animals are often parasites that live inside the bodies of various animals including humans. There are also animals that live independently. Most of them live in water bodies or damp environments. The length of the animals of this phylum can range from one millimetre to almost twenty metres (66 feet).

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: Some systems have been formed, through which physiological functions such as movement and excretion are performed. There is no respiratory system or closed circulatory system. Although there is a muscular system and excretory system, a complete digestive system has not been formed. The muscles of their bodies are arranged in layers and clusters.

Body symmetry: Bi-lateral symmetry is found.

Coelom: Absent.

Presence of body segmentation: Absent.

Type of skeletal system: Absent.

Phylum 4: Nematoda

The Greek word 'nema' means 'thread'. The animals of this phylum are cylindrical, slender, and long. Their difference with flatworms or tapeworms is their cylindrical structure; and this structure is stable for the cavity inside their body. The cavity is filled with water, and provides stability to their structure and acts like a skeleton. Their body has a straight and unbranched digestive tract which extends from the mouth to the anus. The animals of this phylum are also often parasites that live inside the bodies of various animals, including humans. For example, hookworms are a type of worm in this phylum that live in the human intestine. Their bodies are covered with a thick cuticle. As a result, even if the host is inside the digestive tract of the body, the intense digestive juice or enzyme of the digestive tract causes them no harm. There are also animals that live independently. Most of them live in freshwater environments. The length of the animals of this phylum can range from one millimetre to almost seven metres (23 feet).

Major characteristics of this phylum are:

Structure and cellular arrangement: They are simple but have complete digestive system with mouth and anus. Physiological activities like digestion, excretion and movement are done through this system. However, like tapeworms, they also do not also have a respiratory system nor a closed circulatory system.

Body symmetry: Bi-lateral symmetry is found.

Coelom: Although there is no well-developed coelom or body cavity, there is pseudo-coelom. There is digestive system inside it.
Presence of body segmentation: Absent.
Type of skeletal system: There is no skeleton system made of bones. However, as the body cavity is full of water, it gives firmness to the body.

leeches

Phylum5-: Annelida

Have you ever carefully observed the body structure of leeches or worms? If you notice, you will see that the whole body of these animals is divided into numerous segments. It seems as if the body is made up of many small rings attached one after another. For this reason, the phylum comprising earthworms and similar animals is named 'Annelida'. This word has come from the Latin 'annulus' which means ring. The body structure of the animals of this phylum is long cylindrical. In almost all cases, these animals have hair-like stiff setae on their bodies which help them in movement.

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: System is formed by the combination of several organs and through it the physiological activities are done.

Body symmetry: Bi-lateral symmetry is found.

Coelom: True coelom is present.

Presence of body segmentation: Body segmentation is present.

Type of skeletal system: There is no strong skeleton system made of bones. However, as the body cavity is full of liquid, it gives firmness to the body.
Other characteristics: Nervous system, digestive system and circulatory system are present.

Phylum6-: Arthropoda

The word Arthropoda comes from the Greek words 'arthro' and 'poddos', which mean 'joint' and 'foot' respectively. The very name implies that the animals of this phylum have jointed legs. Arthropoda is the largest phylum in the animal kingdom, with around 80 of the invertebrates. Majority of the vast diversity of species of organisms identified on Earth so far falls under this phylum, and this number is more than 12 lakhs! All

insects (such as cockroaches, grasshoppers, etc.), arachnids (such as spiders, scorpion, lice etc.), and crustaceans (such as crabs, shrimps etc.) are animals of this phylum.

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: System is formed by the combination of several organs, and through it the physiological activity is done.

Body symmetry: Bi-lateral symmetry is found.

Coelom: Body cavity or coelom is present. In many cases, coelom is filled with blood.

Presence of body segmentation: The whole body is divided into several particular segments.

Type of skeletal system: They have an exoskeleton or shell made of chitin. Growth of skeleton does not occur during development. So, at different times of life, they moult this skeleton, and grow it anew.

Octopus

Other characteristics: Nervous system, digestive system and circulatory system are present. There are antennae and eyes, in many cases, compound eyes (For example, flies).

Phylum 7- : Mollusca

The name of this phylum has come from the word 'molluscus' which means 'soft'. The appearence of phylum Mollusca prove the reasons of such naming; Among our familiar animals, snail, oyester, octopus etc. belong to this phylum. Their bodies are soft and muscular. They have broad muscular legs and bodies are covered with muscular membrane 'mantle'. Mollusca is the second largest phylum after Arthropoda. Till now more than 100,000 species of this phylum have been discovered. They are primarily nocturnal, can be found in almost all freshwater and marine environments on Earth. However, there are also several terrestrial species. The animals of this phylum are of great variety, colour and shape. This phylum ranges from tiny snails to gigantic squids.

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: A well-developed system is formed by the combination of more than one organ, and all the physiological activities are performed through this system.

Body symmetry: Bi-lateral symmetry is found.

Coelom: Well developed body cavity is present.

Presence of body segmentation: Absent.

Type of skeletal system: Many of the animals of this phylum have a hard exoskeleton made of calcium carbonate (which we see as oyster or snail shells) that protects their soft bodies. Some do not have such skeletons, such as octopus, squid, sea slug etc.

Other characteristics: Prominent head is present. There are well developed nervous system, digestive system and circulatory system. Some of these animals (such as squid and octopus) have the most developed nervous system among invertebrates.

Phylum- 8: Echinodermata

As usual with the animals of this phylum, the characteristics can be estimated only by understanding the meaning of the name. The Greek word 'echinos' means 'spine' and the word 'derma' means 'skin'. So, you can understand from the name, the skin of the animals of this phylum is covered with spine. All animals of the phylum Echinodermata live in marine environment. They do not have a separate head. The main characteristic that can be observed in all animals of this phylum is radial symmetry. In addition to this, the animals in this phylum have another unique characteristic, which is a well-organized water vascular system throughout their body. Through this system, they perform important functions like respiration, food intake, and excretion. Not only that, this system is connected to numerous muscular tubular legs. These tubes contract and expand due to the decrease and increase in water pressure, and this is how these animals move. The animals in this phylum include starfish, sea urchins, sea cucumbers, and so on. Even though these animals may appear very strange, the animals in the phylum Echinodermata have the most similarities with the animals in the Chordata phylum (which includes humans).

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: A well-developed system is formed by the combination of various organs, and all the physiological activities are performed through this system.

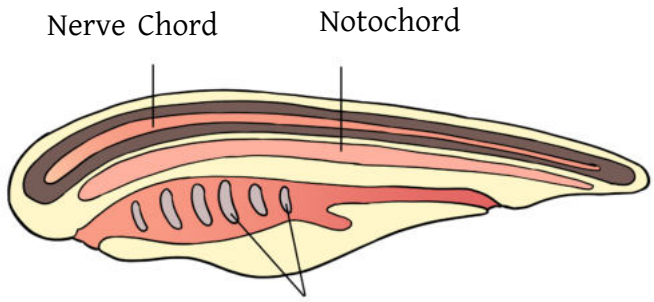
Body symmetry: In the embryonic stage, their bodies are bi-laterally symmetrical, but in

adult bodies, radial symmetry is found.

Coelom: Well developed body cavity or coelom is present.

Presence of body segmentation: Absent

Type of skeletal system: There is endoskeleton made of calcium carbonate inside the body.

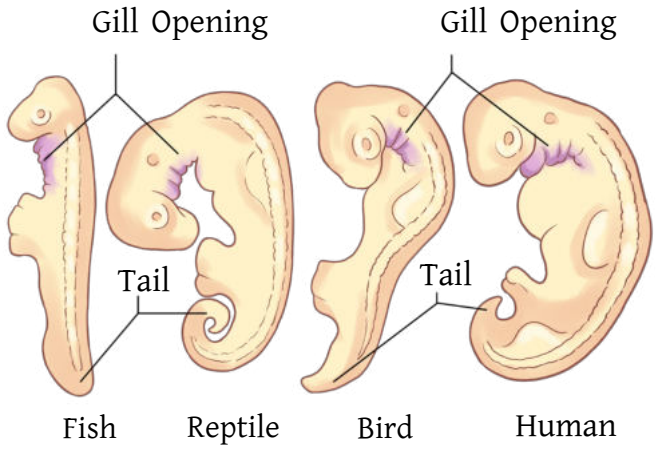


Notochord and Nerve cord

Other characteristics: There is well developed water vascular system that helps in different physiological activities. Many of these animals have the ability to regenerate certain damaged organs of their bodies.

Phylum- 9: Chordata

Among all phyla of the animal kingdom, we are most familiar with the phylum Chordata, because all vertebrate animals including ourselves, that is, humans belong to this phylum. One important thing to remember here is that not all animals in the phylum Chordata are vertebrates. The word 'chorda' means 'string' or 'chord'. In all animals of this phylum, a longitudinal chord called the notochord extends along the back to the end of the body. The notochord is solid and rod-shaped. And just above this notochord there is another rod-shaped chord parallel to it, which is the nerve cord. However, it is not as solid as the notochord, rather like a hollow tube. In vertebrates, the notochord further develops into a stiff spine. The nerve cord develops into a well-structured brain located on top or in the front of the body.



All animals of the phylum Chordata including humans and birds have tails and gill openings in the embryonic stage.

All chordates or the animals of the phylum Chordata have tails and gill slits on both sides of the pharynx. You must be surprised to read this, because we do not see any

of these in the human body. To be honest, if you observe any animal of the phylum Chordata, including humans and birds, during the embryonic stage, you will see that each of them has tails and gill slits. At a phase during the development of humans, these gill slits eventually transform into parts of the ear and tonsils. On the other hand, in case of fish, the gill slits develop into more organized structures, gills that allow them to breathe underwater. The same thing happens with the tail. In the embryonic stage, tails are clearly visible in all animals, including humans, birds, etc. but in many animals, including humans, they disappear later.

Let's have a look at the major characteristics of this phylum at a glance:

Structure and cellular arrangement: A well-developed system is formed by the combination of various organs, and all the physiological activities are performed through this system.

Body symmetry: Bi-lateral symmetry is found in their bodies.

Coelom: Well developed body cavity is present.

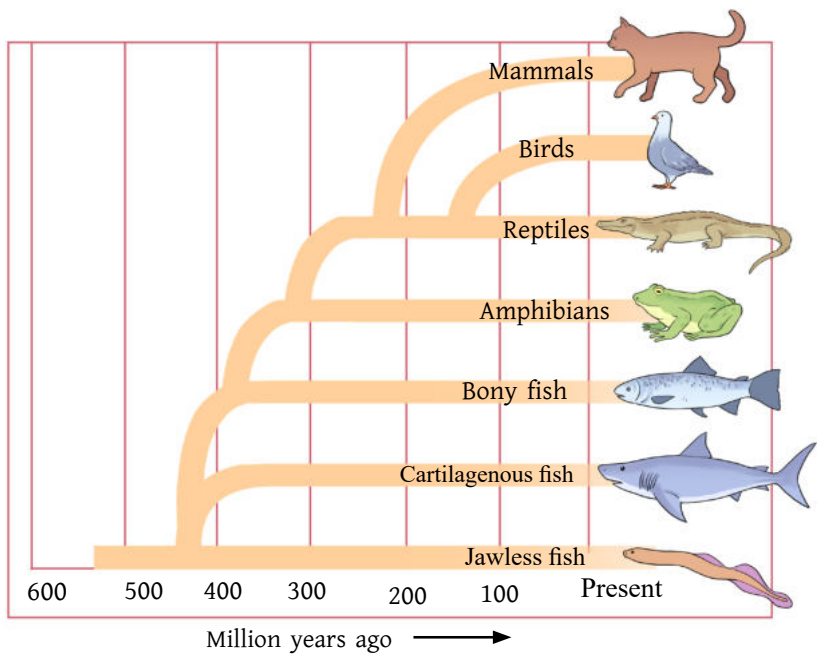
Presence of body segmentation: Body segmentation is present.

Type of skeletal system: There is endoskeleton made of calcium carbonate inside the body.

Other characteristics: Well developed and complete digestive system, nervous system and circulatory system are present. All of them have tail and gill glands at some stage of their life.

The phylum Chordata can be divided into three sub-phyla:

a. Urochordata: They are not motile, and just like marine plants, they attach their bodies permanently to solid



Classification of Vertebrata animals

objects. The inflated body and tube-like structure help them circulate water. Although notochord and nerve cord are present in the larval stage, both of them disappear in adulthood. Their structure is shown in the image below. Example: Ascidia

b. Cephalochordata: Throughout their lives, the presence of notochord and nerve cord can be observed in their bodies. They look like fish. The animals in this sub-phylum are thought to have the closest evolutionary traits to their vertebrate ancestors. Example: Amphioxus

c. Vertebrata: The animals of this sub-phylum are known as vertebrates. Their main characteristics are that they have a distinct head; a spinal cord is formed as an advanced form of nerve cord; and a strong vertebral spine to protect the spinal cord. In addition, their brain is protected inside a hard skull, and it is connected to the spinal cord. The endoskeleton helps these animals in movement. Based on the structure and characteristics, vertebrates are divided into 7 categories. In Class 6, you were told about these seven categories of vertebrates. The categories are-

(1) Jawless fish (Cyclostomata)
(2) Bony fish (Osteichthyes)
(3) Cartilagenous fish (Chondrichthyes)
(4) Amphibians (Amphibia)
(5) Reptiles (Reptilia)
(6) Birds (Aves)
(7) Mammals (Mammalia)

Although platypus is a mammal, it lays eggs.

10.3.3 Mammalia

Mammals belong to a diverse category of creatures. About 6,500 mammals have been identified so far. In general, mammals are animals that live on their mother's milk. They give birth and suckle the child. The word 'mammal' has come from 'mammary gland'. However, there are exceptions to this as well, such as the platypus, which lays eggs but suckles the child with mother's milk after birth. Mammals have bodies covered with fur. All vertebrates are warm-blooded animals, and they have a four-chambered heart. They have lungs.

Among mammals, there are herbivores, carnivores, and omnivores. Almost all mammals have teeth in their mouths. By observing the types of teeth, you can get an idea about the food habits of the animals. Look closely at the structure of the teeth of predatory animals, such as tigers, cats, dogs, wolves. On the contrary, notice the teeth of herbivores like cows, goats, deer, etc. You will be easily able to understand the differences.

As warm-blooded animals, mammals need to maintain the regulation of a constant

body temperature. This is why almost all mammals have hair or fur on their bodies. Not only this, the layer of fat under the skin also helps to maintain the required body temperature and keep the body warm. Therefore, if you observe animals from colder regions, you will notice that in most cases, their fur is dense and large.

Like other vertebrate animals, mammals have a skeleton and a muscular system. These systems work together to allow mammals to move. The mitochondria present in their muscle cells generate the necessary energy for this movement.

Most mammals walk on four legs. However, there are some exceptions. Bats, for example, are mammals that have evolved their front legs into wings. Whales and dolphins, which live in water, have also evolved their front legs into flippers and have lost their hind legs over time.

Most mammals walk on four legs. However, there are exceptions here too. You know that bats are mammals. Their two front legs have actually evolved into wings. Again, think of the aquatic mammals- whales or dolphins. Not only their two front legs have evolved into fins, but also over time, the two back legs have also disappeared.

It is no exaggeration to say that mammals are the most complexly evolved animals on Earth. Their brains are capable of complex analysis. Besides, and their sharp senses allow them to collect and respond to a lot of information from their surrounding environment. You will learn a lot more about these animals in the future.

10.4 Insects

Insects have been living on Earth since the prehistoric times. Approximately 40 to 45 crore years ago, insects appeared on Earth. After that, they have dominated almost all ecosystems on Earth for a long time. During that time, insects were also quite large in size; a single dragonfly was the size of a seagull. Over time, with the course of evolution, birds, reptiles, and mammals emerged on Earth. Simultaneously, the impact of insects decreased. However, even though they have become smaller in size, insects are still unparalleled in species diversity and number. Even today, there are countless species of insects all around us. Insects are the most diverse group of animals on Earth, and about 80 percent of the discovered animal kingdom is insects. There are over ۱ million described species of insects.

The body of an insect is divided into three parts: head, thorax and abdomen. The body is covered with a hard exoskeleton made of chitin. The exoskeleton protects the body. It also acts as a connection point for various muscles. Insects molt, or shed their exoskeleton, as they grow. Insects are unique in that they have only three pairs of

thoracic legs and most insects have two pairs of thoracic wings. Insects exhibit diverse forms and shapes. Some insects are less than a millimetre long, while others can have wingspans of several centimetres. The life span of insects can range from a few hours to many years; they can live in isolation or in social groups. Insects feed on a variety of plants, animals and organic matter. Their relationships with food sources can range from mutualism to parasitism or predation. Insects have well-developed digestive, circulatory, respiratory, nervous, and reproductive systems. Digested food is absorbed mainly in the middle part of esophagus.

Insects are small animals, but their life cycle is quite complex and diverse. Almost all types of insects go through three or four stages in their life cycle. The butterfly completes four stages in its life. First, the female butterfly lays eggs, then the eggs hatch into larvae, the larvae turn into pupae, and the pupae turn into adult butterflies. Grasshoppers complete three stages in their life- eggs, nymphs, and adults. This type of change in the life cycle of insects is called metamorphosis. Though many insects live individually, some insects live in groups and lead a social life. Their communal living is somewhat similar to human social life. The responsibility of work is divided in the social life of insects. Each group consists of a queen, several males, and numerous workers. Due to their social life, a certain division of labour is observed among them. As a result of social life, a type of division of labor is seen among them. The workers engage themselves in all kinds of work including food collection, maintaining shelter, and other chores. The queen and males mainly contribute to the growth of the population. Insects are a diverse group of animals that include everything starting from tiny ants to the cockroaches in the corner of our house, and even colourful butterflies and grasshoppers. From the soil to the trees, water bodies, crop fields, and even in our homes, we encounter them. They can be found in a variety of habitats, including soil, plants, water bodies, crop fields, and even our homes. These creatures wandering on the Earth for billions of years have been an inseparable part of nature. The relationships and food webs among various animals and plants in the environment cannot be imagined without insects.

Although we generally know insects as harmful, they have an immense beneficial role in nature. Insects play a vital role in the ecosystem, starting from the pollination of plants to maintaining the overall order. They contribute to other animals' food supply too. Birds, bats, and small mammals all feed on these insects. So, if there were no insects, birds, bats, frogs, and sweet-water fish would also disappear. Insects are either food for other animals or servants of the ecosystem. Although some insects are harmful, the

majority of species benefit us directly or indirectly. Among the notable insects are bees, butterflies, silkworms, and grasshoppers etc. Bees collect honey from flower to flower and store it in beehives. Honey and wax are two of the most important natural resources. Bees also play an important role in the pollination of various crops. Silkworms are another important insect. Through sericulture, silkworms are raised to produce silk thread, which is used to make valuable textiles. Butterflies and grasshoppers are the most attractive insects. The fluttering of colorful butterflies instantly fascinates people. Insects are not only beautiful and colourful, but they also play an immense role in maintaining the biodiversity by pollinating from flower to flower. Another well-known group of insects is ants. They create homes in holes in the soil, in tree hollows, or in the gaps of various furniture. They are very social. They move in a line and collect food together. They measure the angle of sunlight to return home and gather food. They help keep the environment beautiful by eating our leftover food and other dead insects.

10.5 Position of Humans in Animal Kingdom:

Biologists classify animal kingdom into different species. Animals that can produce reproductive offspring through sexual intercourse are considered to belong to the same 'species'. Species that have evolved over time from a common ancestor in the past are included in a group called 'Genus'. Even though tiger, lion, leopard, and jaguar are different species, each of them belongs to the genus Panthera. Following the method of scientist Carolus Linnaeus, biologists have given each organism a binomial Latin name, the first part of which indicates the genus and the later part the species. For example, the scientific name of the lion is 'Panthera leo', where 'Panthera' and 'leo' refer to the genus and species respectively. The scientific name of humans is Homo sapiens. Here 'Homo' (human) is the genus name and 'sapiens' (wise) is the species. The closest relatives of humans- chimpanzees, gorillas, and orangutans are still living. They are all in the genus 'Homo'. In the hierarchical classification of the animal kingdom, humans belong to the phylum Chordata, the sub-phylum Vertebrata, the class Mammalia, the order Primate, the family Hominidae, the genus Homo, the species sapiens.

Classification of Humans:

Phylum : Chordata
Sub-phylum: Vertebrata
Class: Mammalia
Order: Primate
Family: Hominidae
Genus: *Homo*
Species: *sapiens*

CHAPTER 11

GEOGRAPHICAL COORDINATES, LOCAL TIME, & REGIONS

ভৌগোলিকভাবে বিশ্বের অন্যতম গুরুত্বপূর্ণ পয়েন্ট, কর্কট ক্রান্তি এবং ৯০ ডিগ্রি দ্রাঘিমার ছেদবিন্দু, বাংলাদেশের ফরিদপুরের ভাঙ্গা উপজেলায় নির্মিত হতে যাচ্ছে একটি সুরম্য মানমন্দির; ছবিতে সেই মানমন্দিরের নকশা

CHAPTER 11

GEOGRAPHICAL COORDINATES, LOCAL TIME, & REGIONS

This chapter deals with the following topics:

- ☑ Geographical Coordinates:
- ☑ Latitude
- ☑ Longitude
- ☑ Prime Meridian
- ☑ International Date Line
- ☑ Various Environmental Issues and Human Roles in Different Geographical Regions

Have you ever noticed how people describe their location to one other? For example, when you need to find someone's house, just telling the name of the area is not always enough. In such cases, you have to describe the location of the house in relation to a specific landmark, shop, or building. This is called Relative Location. This method can be used for a small area, but it becomes quite challenging to describe the location of something on the entire surface of the Earth in this way, and in many cases, it's impossible. In such situations, what is used is Geographical Coordinates or Absolute Location.

11.1 Geographic Grid

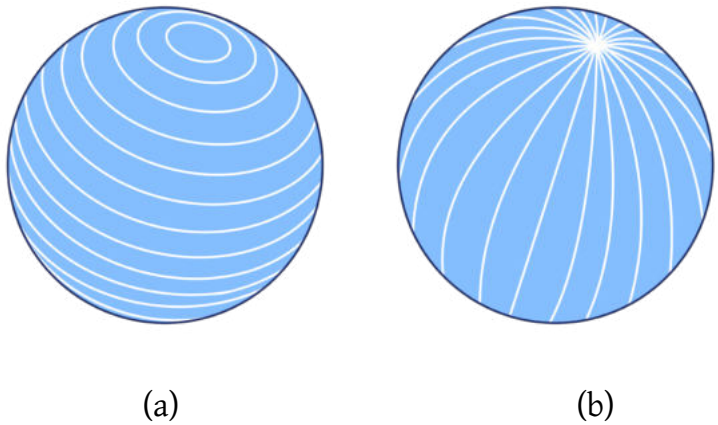
To define the geographic coordinates of any location on Earth, two types of imaginary lines are used:

(1) Lines of Latitude or Parallels,

(2) Lines of Longitude or Meridians.

To understand the concept of these lines, we must envision the Earth as a three-dimensional sphere. On paper, we draw a circle to represent the Earth, but it is not so, rather it is like a ball. If we draw some parallel lines horizontally on a ball or anything spherical (See

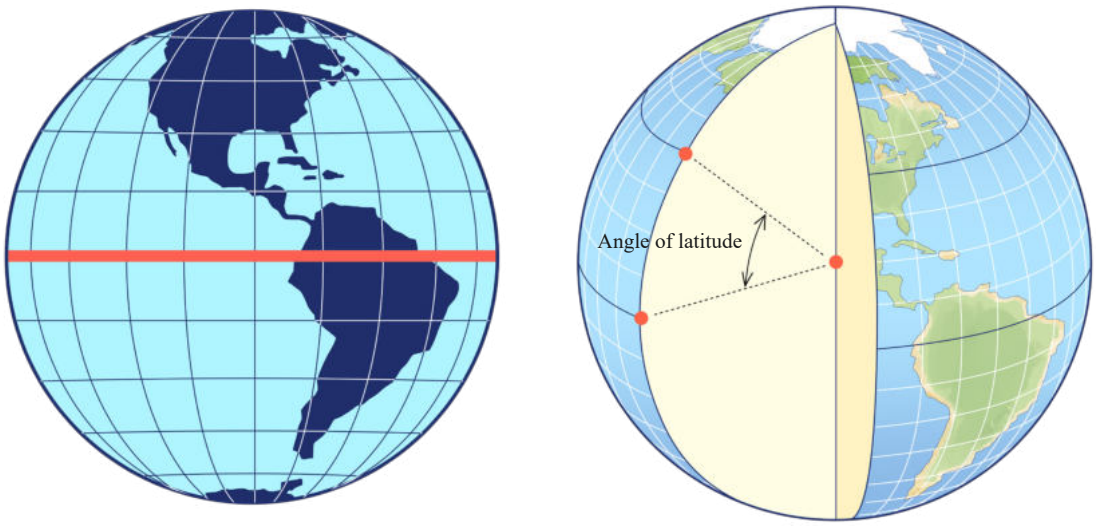
Figure), they will become circular lines going around it. At the very top and bottom, there will be two points, which will be the North and South Poles of the Earth, respectively. This representation is similar to the concept of lines of latitudes or Parallels of Earth. As these circles go towards the poles, they get smaller. Now, instead of drawing parallel lines, if we draw vertical lines from one pole to another, they will represent the lines of longitude or Meridians. That means, the horizontal lines imagined on the surface of the Earth along east-west direction are Parallels, and vertical lines from one pole to another, along north-south direction are Meridians.



(a) Lines of Latitude extend from east to west across the Earth, forming concentric circles, which converge at the poles, resulting in small lines meeting at the meridian points. (b) Lines of Longitude consist of a series of semi-circles extending north to south, of equal lengths, stretching from one meridian to another.

Besides Parallels and Meridians, we also use the values of Latitudes and Longitudes to denote a coordinate of a specific point on Earth. What are the differences between the two measurements? Firstly, Parallels and Meridians are lines, while Latitudes and Longitudes are angles. A specific latitude is drawn for a specific angle, so the value of latitude is the same at every point on a longitude line. Similarly, a specific longitude is drawn for a specific angle, so the value of longitude is the same at every point on a latitude line. Every point on the Earth surface have one latitude and longitude. If we have the latitude and longitude of any place on Earth, we can precisely identify its location.

Therefore, the measurement of latitude or longitude of a place is the angular distance of it from two individual reference lines (angular distance means it represents the angle between two lines or surfaces). As a result, we use angles to measure these geographic coordinates, the unit of which is degrees. Here, 90



(a) Latitude is measured in relation to the Equator. The Equator is an imaginary line that encircles the Earth from east to west, running through its middle. (b) The angle of latitude originates at the center of the Earth. In other words, if we take the intersection points of the equator and a parallel of latitude (latitude line) with the same meridian (longitude line) on the Earth's surface, and then connect the intersection points to the center of the Earth, we will obtain the same value of the angle, as was the latitude.

degrees make a right angle, 60 minutes make 1 degree, and 60 seconds make 1 minute. Note that there is no direct relationship between seconds and minutes used to measure angular distance to that of time measurement.
Now, let's delve into some more detailed aspects of latitude and longitude.

11.2 Latitude

Latitude is used to determine how far north or south a location is from the Equator. To understand this clearly, let's first discuss about the Equator. The Equator is an imaginary line that encircles the Earth through its middle, that is, equidistant from the North Pole and the South Pole. It runs

along the east-west direction. The equator divides the Earth into the northern and southern hemispheres. To describe how far a place is located from the equator, we use latitude lines or parallels. Equator acts as the line of reference in the measurement of latitudes. Latitude ranges from 0^0 at the equator to a maximum of 90^0 at the poles. (Note that 0^0 latitude is called the equator, and 90^0 latitude can either be the North Pole or the South Pole which we write as 90^0 North and 90^0 South respectively). You've already learned that every Line of Latitude makes a full circle and is parallel to one another.

The equator makes the biggest circle and the circles get smaller as they go towards the poles, meeting as two dots. As a result, North Pole and South Pole latitude lines are represented by two dots.

Latitude is measured in angles. Now, a question may arise: which two lines create this angle, and where does it originate? When we want to determine the latitude of a place, we imagine a line (See figure) from the place to the center of the Earth, and another line on the same plane from the equator to the same center point (later we will see that being in the same plane means being on the same meridian). The angle formed by these two lines is the latitude.
Latitude ranges from 0^0 to 90^0, and although there are several parallel lines of equal distance (latitude lines) on the Earth, some of them are particularly significant due to various special reasons. (While these latitude lines are parallel circles on the Earth or the globe, they are depicted as parallel lines on maps.) The important latitude lines are:

11.2.1 Equator

This is the 0^0 latitude. The line of Equator runs along the east-west direction, dividing the Earth into two hemispheres known as the Northern Hemisphere and the Southern Hemisphere. An interesting fact—on March 21st and September 23rd, sun's rays falls perpendicularly on this line at noon. On these two days, the duration of day and night is equal everywhere on Earth.

11.2.2 Tropic of Cancer

This is the latitude line located at approximately 23.5^0 North of the Equator. It passes over Bangladesh. On June 21st every year, at noon (12:00pm), the sunlight falls perpendicularly over all the places on the Tropic of Cancer. On this date, the duration of daylight is the longest in the Northern Hemisphere and the shortest in the Southern Hemisphere.

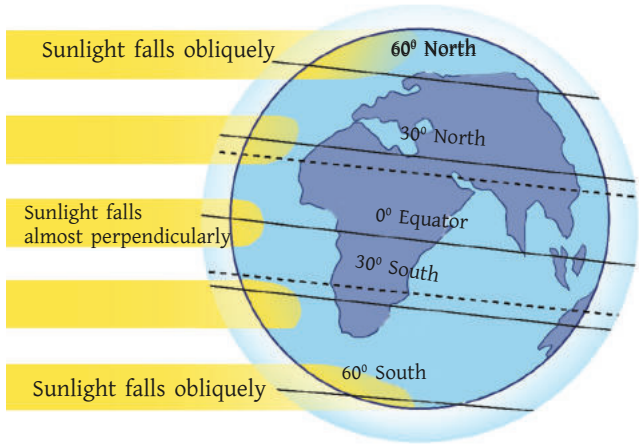
11.2.3 Tropic of Capricorn

This is the latitude line located at approximately 23.5^0 South of the Equator. On December 22nd every year, at noon (12:00pm), the sun is directly over all the places on the Tropic of Capricorn. On this date, the duration of daylight is the longest in the Southern Hemisphere and the shortest in the Northern Hemisphere.

11.2.4 Polar Circle

These are two latitude lines, the Arctic Circle and the Antarctic Circle, situated at

approximately 66.5^0 north and south of the Equator, respectively. The sunlight never falls vertically at the places that are located north of the Tropic of Cancer and south of the Tropic of Capricorn. These places exhibit extremely long days during the summer season and extremely long nights during winter. In fact, on June 21st every year, within the area surrounded by the Arctic Circle, the sunlight remains for 24 hours, which means a full day of continuous sunlight. Similarly, on December 22nd in the same area, there are 24 hours of continuous darkness. The opposite occurs in the region surrounded by the Antarctic Circle.



The Equator or its vicinity receives the sunlight almost perpendicularly. As a result, the sunrays travel relatively shorter distances and experience less spreading of sunlight, making the places they hit on Earth's surface more heated. On the other hand, near the poles, the sunlight falls obliquely. Consequently, it covers longer distances in the atmosphere, spreads over a wider area it on the Earth's surface and the intensity or heat of the sunlight decreases. As a result, all those regions remain colder.

11.3 SIGNIFICANCE AND USES OF LATITUDE

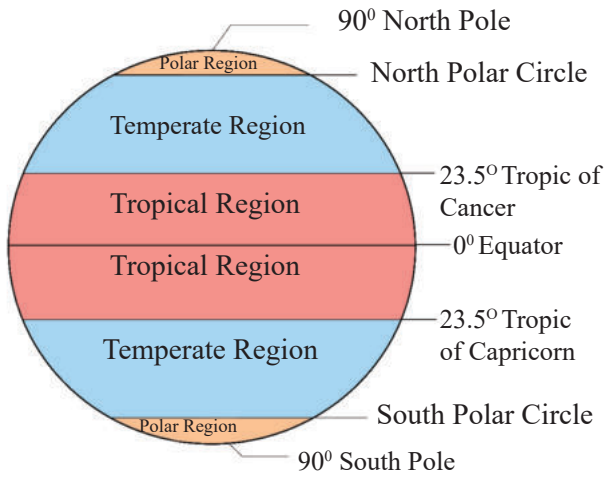
Knowing the latitude of a place is essential to determine the geographical location of that place, and to understand its climate and weather. We know that the axial tilt of the Earth is inclined at an angle of 23.5^0 instead of being perpendicular (90^0) to the plane of its orbit, resulting in the Sun's rays striking the Earth obliquely. As a result, at different latitudes, we receive varying amounts of heat and solar energy (insolation) from the Sun. The intensity of this solar radiation varies at different locations and times of the year, and this, in turn, allows us to experience different seasons throughout the year.

Since the amount of sunlight falling on a location depends on its latitude, the temperature and amount of precipitation are also dependent on latitude. The airflow and ocean currents are also influenced by latitude. Even the nature of land and the characteristics of the living organisms in a particular place are influenced by latitude.

11.3.1 DIFFERENT REGIONS DIVIDED ON THE BASIS LATITUDES:

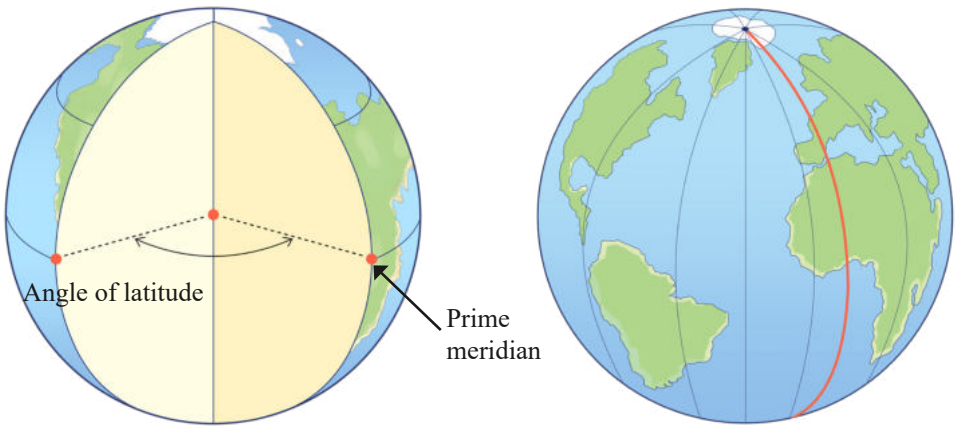
The Earth is divided into several regions based on latitude. Each of these regions has

distinct characteristics regarding their climate, vegetation, wildlife, and even the structure of the land that sets them apart from other regions. The important divisions based on latitude are the equatorial region, the tropical region, and the polar region. The area between the Tropic of Cancer and the Tropic of Capricorn is known as the tropical region. The region between the Tropic of Cancer and the North Pole is the North Temperate Zone, while the region between the Tropic of Capricorn and the South Pole is the South Temperate Zone. In our country, Bangladesh, the Tropic of Cancer passes right through the middle. Therefore, the southern region of this country is a tropical region, and the northern region is a temperate region.



Various regions divided based on latitudes

Question: Have you ever crossed the Tropic of Cancer? "If you were located on the Tropic of Cancer, 12:00 at noon on June 21st, you would not have any shadow"—what



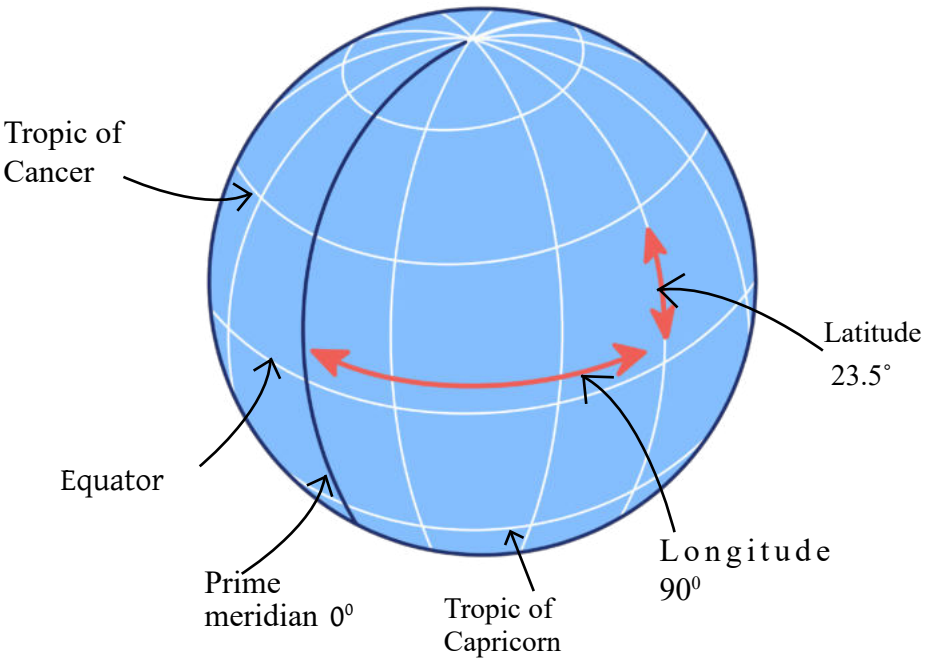
(a) The Prime Meridian is an imaginary semicircular longitude line that extends from the North Pole to the South Pole, passing through the city of Greenwich, England. (b) The angle of longitude is also measured from the center of the Earth. In this case, if we connect the two intersection points—one of the prime meridian, and the other of the longitude line containing the place, with the equator to the center of the Earth, it will be the angle of longitude at that point.

does this statement mean?

Question: Is your school located in the tropical region or the temperate zone?
Question: Do you know that 'meter' (m), the unit of length, is defined in such a way that if you move exactly one hundred kilometer north or south on the Earth's surface, your latitude will change by 1 degree? Calculate and show if this fact is true. (The radius of the Earth is 6,000 kilometers)

11.4 Longitude

Longitude refers to how far a specific location on Earth is to the east or west of a certain reference meridian. A line indicating longitude is called a meridian. The reference line from which east or west longitudes are measured is known as the Prime Meridian. It passes through Greenwich, England. Each meridian is a semicircle, and all meridians have the same length. Meridians spread out from one pole to another and all of them connect at both poles. Every meridian intersects the equator perpendicularly.



The Tropic of Cancer and the 90^0 west meridian intersect in Bangladesh, so we can say that Bangladesh's location is at 23.5^0 north latitude and 90^0 west longitude.

The value of longitude ranges from 0^0 (prime meridian) to 180^0 to the east and west. Did you know that Bangladesh is crossed by the 90^0 meridian, which lies precisely

between the Prime Meridian (0^0) and the 180^0 meridian? Since the value of longitude remains the same at any point north or south along a line of longitude, the easiest method to determine the longitude of any location on Earth is by measuring its longitude on the equator. The angle made by the lines connecting the center of the Earth to the two intersection points on the equator—one with the Prime Meridian and another with the specified meridian—is the angle of that longitude.
Some meridians are significant for special reasons, such as—the Prime Meridian and the International Date Line.

11.4.1 PRIME MERIDIAN

The meridian passing through the Royal Observatory in Greenwich, located near London, is known as the Prime Meridian, and its value is 0^0. It is essential to note that the prime meridian has no east-west direction; instead, it divides the Earth into the eastern and western hemispheres.

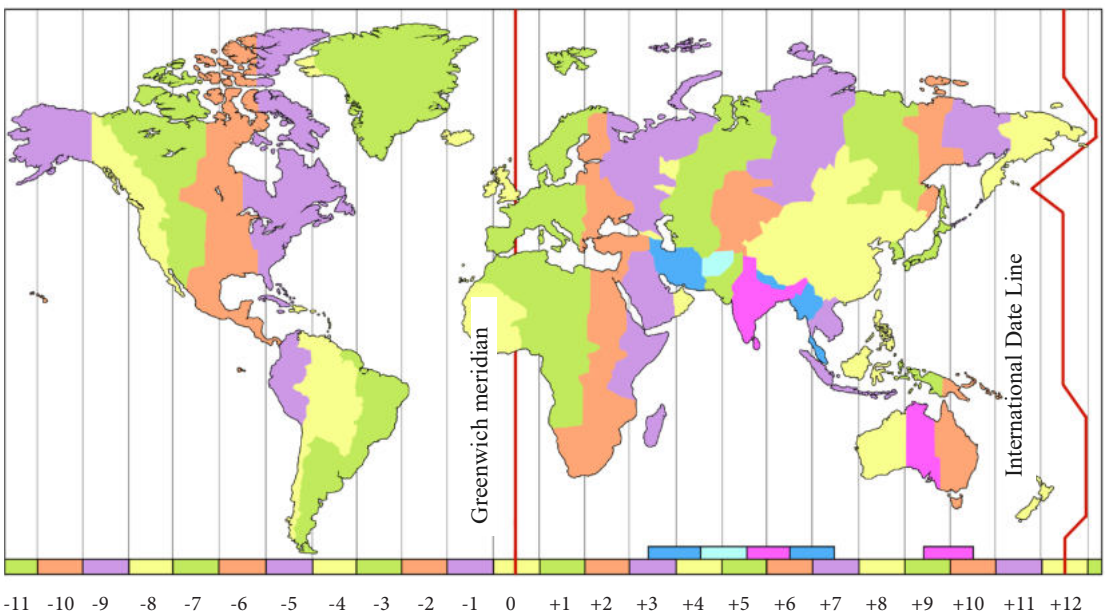
11.4.2 INTERNATIONAL DATE LINE

We've learned that each longitude line forms a semicircle. Therefore, the longitude line exactly opposite the Prime Meridian (0^0) has a value of 180^0. This meridian also has no east-west value. This particular longitude line is known as the International Date Line. The concept of this line was established for the purpose of calculating time and date across different countries and regions. Different dates are counted on either side of this line. Though it may seem a bit peculiar, it is highly essential. If someone crosses this line towards the east, they will move ahead to the next date! Conversely, if they cross it from east to west, it will be the opposite. However, this concept is not as strange as it sounds. Due to the different positions of countries on Earth surface, sunlight reaches different places at different times. Therefore, they experience sunrise and sunset at different times. Some places have daytime while others have nighttime at the same moment. When someone says it is 4 PM in their country, it might be a completely different time for those on the opposite side of the Earth on the other hemisphere. The International Date Line is useful in such cases to determine the difference of date and time at two places at the same moment.

This line has another notable characteristic. You might find it drawn as a curved line (on a globe) or as a zigzag line (on a connected world map). This is done to have it pass only through the water (of the Pacific Ocean) in order to avoid any single country or region experiencing two different dates simultaneously.

11.4.3 DETERMINING GEOGRAPHIC LOCATION USING LONGITUDE

We already know that latitude tells us the north-south position of a location or point on Earth, but for its east-west position, we need to know the longitude. Longitude and latitude are used together to determine the precise location of any place on Earth. When both lines intersect, they create a imaginary grid-like structure on the Earth surface, or a globe (Earth's model in small scale) or a map. This grid is called a Graticule. By knowing the longitude and latitude of a specific location on the graticule, we can pinpoint its exact geographic location. Moreover, the value of longitude is also crucial for determining the time and date at a particular place.

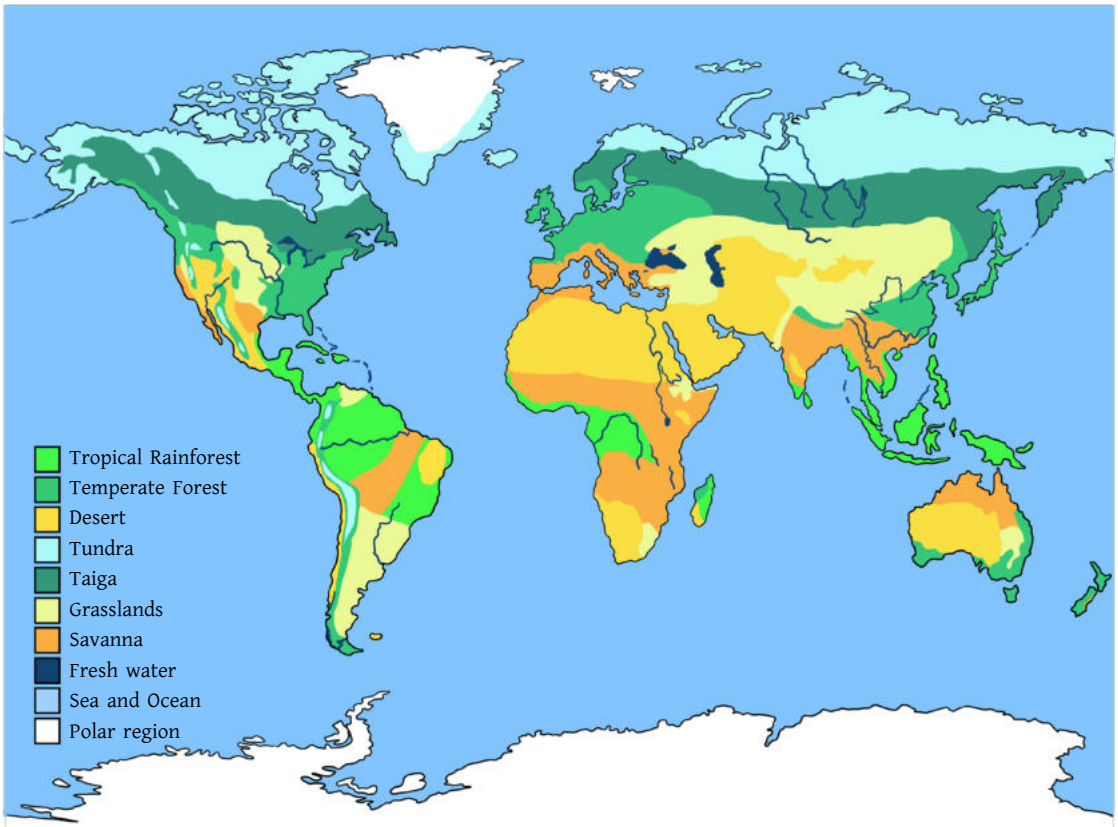


International Date Line and different Time Zones. Bangladesh's time zone is GMT6+.

11.4.4 DETERMINING TIME AND DATE

The Prime Meridian (0^0 longitude) passes through Greenwich, so the time of any location on Earth is determined in comparison to the time of Greenwich at that moment. If we start from any line, travel around it completing a full circle and get back at the starting point, we will find that the total angle traveled is $360^0 = 180^0 + 180^0$. This is also true for longitudes. The angle in east and west direction from the Prime Meridian is 180^0 each, which means 360^0 in total. One day has 24 hours, so crossing every $(360 \div 24 =) 15°$ of longitude results

in a time difference of 1 hour. As we mentioned earlier, moving eastward from the Prime Meridian increases the time on clock, and moving westward decreases it. The time difference is indicated by a positive (+) sign for the areas east of the Prime Meridian and a negative (-) sign for areas west of it. Earth is divided into several time zones by aligning them with the meridians and the International Date Line. Bangladesh falls under the GMT6+ time zone, meaning when it is 12:00 PM (noon) in Greenwich, it is 6:00 PM (evening) in Bangladesh.



Different types of Geographical Regions on Earth

The difference between the Prime Meridian and the International Date Line is 180^0 so there is a -12hour time difference on clock between the two places. Now, if two individuals travel from the Prime Meridian, one towards the east and the other towards the west, and both cross the International Date Line, then the traveler heading east will have a time that is 12 hours ahead of the starting time on clock, while the traveler heading west will have a time that is 12 hours behind the starting time on clock. This can create confusion with the date. To address this issue, it was established that when someone crosses the International Date Line heading eastward, they need to set their

clock one day back. Similarly, when someone crosses the International Date Line heading westward, they need to set their clock one day ahead. For instance, consider you are traveling eastward at high speed and cross the 180^0 longitude. In that case, you will have to set your watch one day behind. So, if it's the 21^{st} of February today, your watch should show the 20^{th} of February after crossing the International Date Line.

Formation of different Geographical Regions due to the effect of Latitude conditions: (Top) Polar Region & Tundra Region (Bottom) Desert Region & Evergreen Forest

11.5 DIFFERENT TYPES OF GEOGRAPHICAL REGIONS

We have already learned that different regions of the Earth have various climates, ecosystems, and geological features based on their latitudinal position. Now, let's explore how these differences can manifest.

11.5.1 POLAR REGIONS

The area surrounding both geographic poles of the Earth are known as the Polar Regions. Due to their proximity to the poles, the sunlight falls at an oblique angle in these regions, so the temperature in these regions is very low. The main characteristics of this region are extreme cold temperatures, vast and thick ice covering, and limited presence of plant and animal life. The Northern Polar Region is located in the Arctic

Ocean, surrounded by Greenland, Canada, Russia, and northern parts of Alaska. On the other side, the Southern Polar Region is located, and known as the Antarctic continent. Both Polar Regions experience long periods of daylight in summer and darkness during winter. Due to the adverse conditions, the plant life in the Polar Region mainly consists of mosses, lichens, and shrubs. Additionally, various species of animals such as polar bears, penguins, Arctic foxes, walruses, seals, and several types of whales inhabit this region. The majority of the landmass is covered with ice, and the movements of the ice sheets or glaciers govern the topography of these regions.

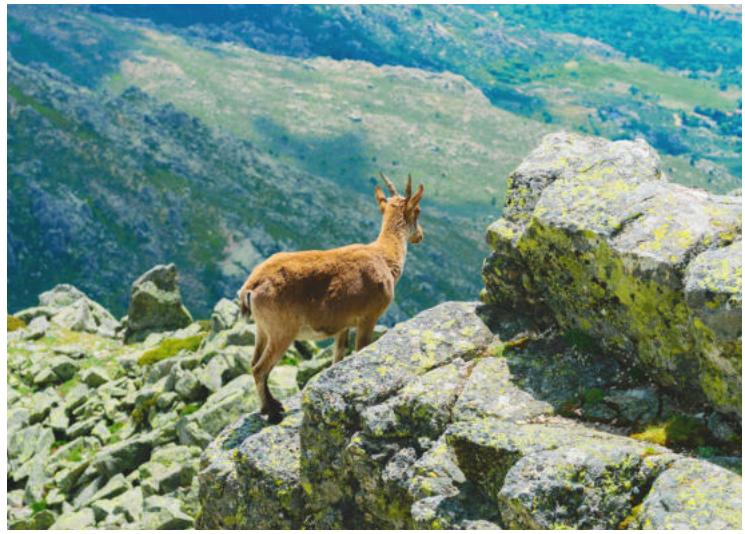
11.5.2 TUNDRA REGION

The Tundra region is a vast area located in the northern hemisphere, especially in the Arctic region, where cold-tolerant plants and vegetation can be found. These regions are mainly found in Alaska, Canada, Russia, Greenland, and some parts of Scandinavia. However, in many cases, tundra-like characteristics can also be observed near the peaks of high mountains. The main characteristic of this region is its cold temperature and frozen soil. The growing season for both plants and animals are limited in this area. Due to the low precipitation, mainly in the form of snowfall, this region is referred to as a 'cold desert'. Despite the harsh environment, various types of vegetation and animals can be found here. Among the vegetation, there are different types of mosses, grasses, and shrubs. Caribou, reindeer, polar bears, arctic foxes, and various species of birds (such as snow owl and ptarmigan) are some of the animals that can be found in this region.

11.5.3 DESERT REGION

The characteristic of the desert region is extreme dryness, with annual rainfall of 250 millimeters or less. There are some areas where rainfall has not occurred for several years. Deserts are mainly found in the subtropical regions, that is, along the Tropic of Cancer and Tropic of Capricorn. The key feature of desert areas is their dry and arid climate, where there is a significant temperature change between day and night. Due to the scarcity of water and vegetation, these areas can be extremely hot during the day and experience extreme cold at night. The limited availability of water supports life for only a small number of plants and animals. These plants have a waxy covering on the outer surface that prevents water from evaporating. They also have long roots that can draw water from deep beneath the ground. Moreover, these plants can survive in adverse environments through various adaptive processes. Some of the vegetation in these areas have adaptations such as succulence, allowing them to store water and survive in such harsh conditions. The animals inhabiting this region have also developed special

adaptations to survive in the desert, such as—being nocturnal, burrowing to escape the heat, storing water in their bodies, and being capable of surviving with minimal water intake. Common desert animals include camels, rattlesnakes, scorpions, fennec foxes, etc.



Mountainous regions are formed by the collision of tectonic plates due to the influence of latitude.

11.5.4 EVERGREEN FOREST

The evergreen forest is a dense forest area that remains green throughout the year, even in dry weather. Such forests are mainly found in regions where the temperature and rainfall are relatively high, especially in the tropical and equatorial regions. The density of trees is so high in these forests that very little sunlight can penetrate through the canopy to reach the forest ground. Generally, the leaves of the plants in this forest are green and large, which can absorb abundant sunlight. Additionally, these plants can draw a significant amount of nutrients from the soil along with water. Among the various geographical regions, the evergreen forests host the widest variety of plant and animal species. Indonesia's rainforests, the Congo Basin, and the Amazon rainforest in South America are some examples of evergreen forests. Due to the abundance of green vegetation, these forests absorb a significant amount of carbon dioxide from the atmosphere and release oxygen. Various species of monkeys, sloths, jaguars, snakes, and birds can be found in these forests. Ferns, epiphytes, red cedar, cycads, and blue spruce are among the diverse range of plants abundant in the evergreen forest.

11.5.5 MOUNTAINOUS REGION

The geographical regions mentioned above are influenced by their latitudinal positions. However, the formation of mountainous regions primarily occurs due to the creation of mountains resultedby the collision of tectonic plates. The mountainous areas are full of significant diversity and adversity. The characteristics of the soil and climate in this

area are dependent on its altitude and slope. The high elevation and steep slopes create various microclimates within this region, which supports the survival of different types of plants and animals. The plants here have the ability to take root in rocky terrain, tolerate extreme temperature variations, and store water in their bodies. Animals here also have adaptive features, such as, ability to climb steep slopes, adapting to cold and hot climates, having thick fur for staying warm in the cold months, and a tendency to hibernate during the cold seasons, etc.

11.6 DIFFERENT ENVIRONMENTAL ISSUES IN VARIOUS GEOGRAPHIC REGIONS AND THE ROLE OF HUMANS

Different geographic regions have different types of environmental issues, and humans play a crucial role in both creating and solving these issues.

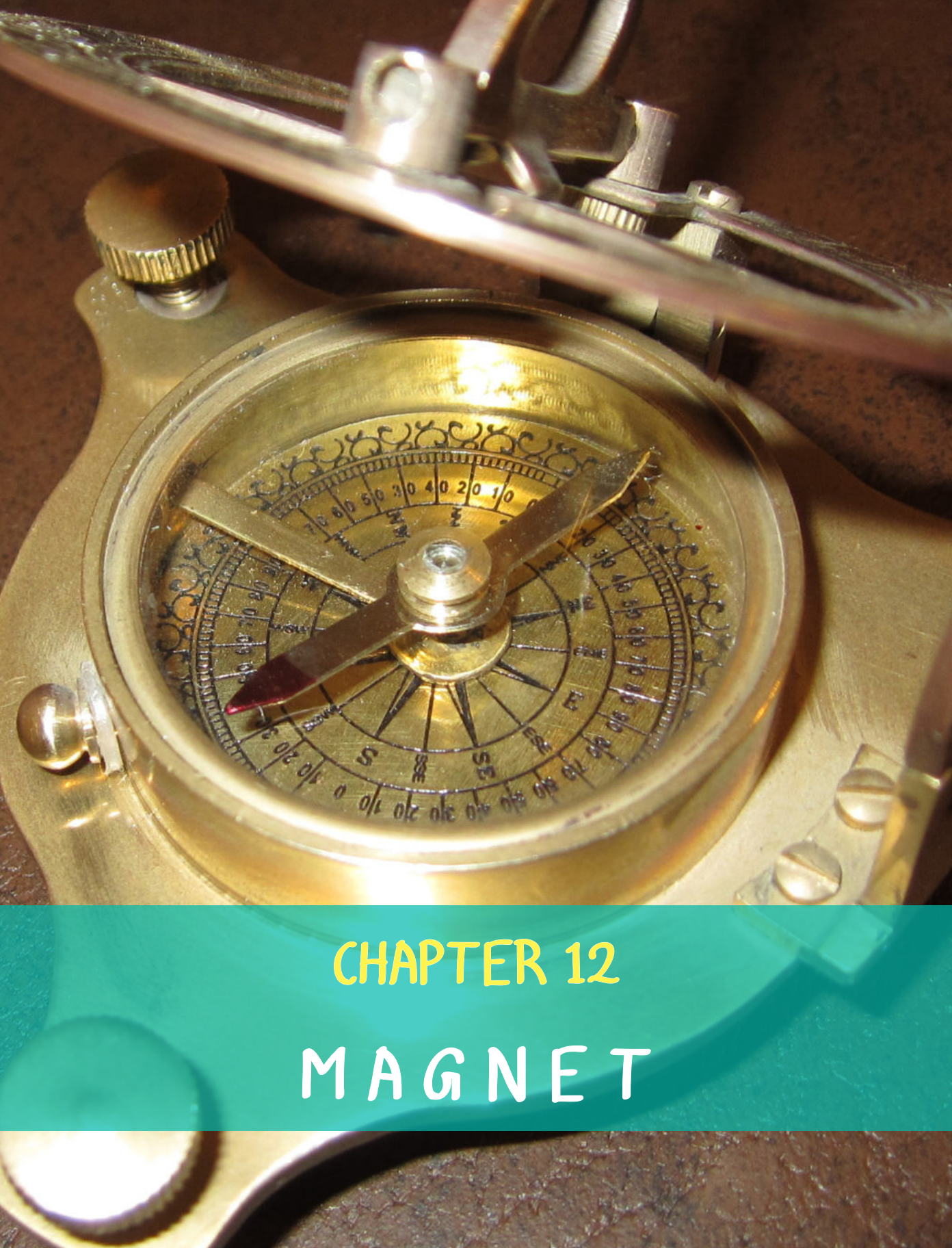
The effects of climate change are significantly affecting the mountainous and tundra regions. Due to the melting of ice in these regions, the sea level is rising, and the habitat for polar bears, reindeer, and other animals is decreasing. Forest conservation, sustainable development, and reducing greenhouse gas emissions can be significant steps in protecting these regions.

In desert regions, excessive livestock grazing and oil extraction lead to soil degradation and loss of biodiversity. However, through sustainable agricultural practices and conservation policies, all these issues can be addressed.

The evergreen forests are facing a severe threat to their biodiversity and change in climate due to excessive deforestation. Conservation of forest resources, sustainable forest management, and careful planning can play a crucial role in protecting these forests.

In mountainous regions, soil erosion and loss of biodiversity are happening because of various mining activities and deforestation. By implementing afforestation schemes and sustainable tourism management, these regions can be conserved.

In conclusion, through proper planning, sustainable development practices, and conservation efforts, human involvement can make a significant impact in tackling environmental issues in all regions. It is our responsibility to identify the various harmful impacts we pose on the environment, so that we can work towards eradicating them in order to preserve the environment and its resources for our future generations.



CHAPTER 12

MAGNET

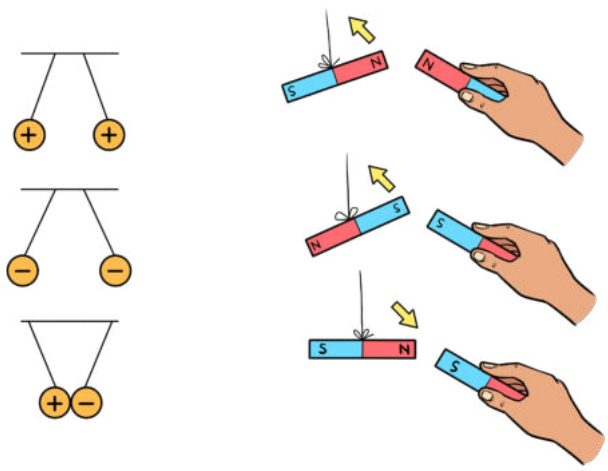
CHAPTER 12 MAGNET

This chapter deals with the following topics:

- ☑ Permanent Magnet
- ☑ Electromagnetism
- ☑ Electromagnet
- ☑ Electromagnetic Induction
- ☑ Magnetic Field of Earth

We use magnets every day in various ways. When we talk on our phone, there is a magnet in the phone's speaker that creates a magnetic field and produces sound in the speaker. Not only in phones, but magnets are also present in the speakers of radios, televisions, computers, laptops, tablets, and similar devices. When we use a fan on hot days, a magnet is used to rotate the motor of the fan. Not just fans, but in air conditioners, refrigerators, and other electrical appliances, magnets are used whenever electricity is used to make something rotate. The electricity we use every day is generated by electrical generators, where a large magnet is rotated rapidly within a coil of wire to create a strong magnetic field.

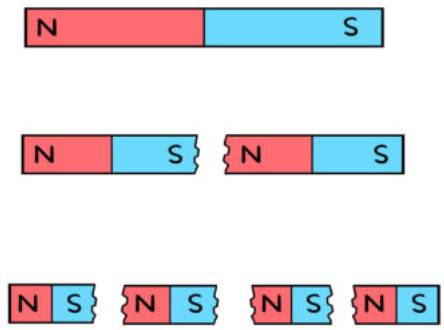
Our Earth itself one giant magnet! The magnetic field of the Earth magnet diverts charged particles coming from the Sun at high speed towards the Earth and protects the animal kingdom from their impact. It is speculated that if the Earth's magnetic field did not protect the Earth, the emergence of life on the planet might have been impossible. Earth would have been a barren, lifeless rock.



Just as similar charges repel each other and opposite charges attract, the same way in a magnet, similar poles repel each other, and opposite poles attract each other.

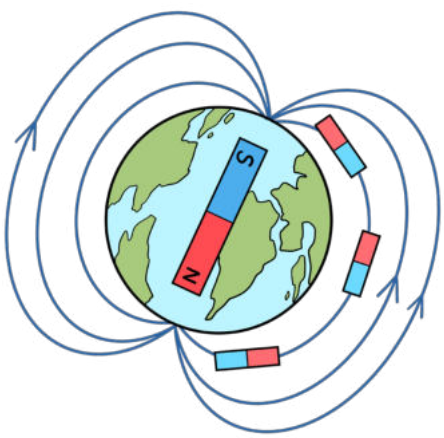
12.1 PERMANENT MAGNET

Those of us who commonly use magnets are familiar with two types of magnets—one type is the permanent magnet, which means it is always magnetic and attracts iron in its natural state. The other type is the electromagnet, which is created by the flow of electricity and gets its name from that. We can stop the magnetic properties of electromagnets by turning off the electric current in them. Since we can control electromagnets manually, we use them more frequently in our daily use of technology.



One pole of a magnet can never be separated by breaking it in two.

When you studied atomic structure, you learned that atoms are composed of electrons and protons. Electrons have a negative charge, while protons have a positive charge. Opposite charges attract each other, and charges of the same type repel each other. Those of you who have had the chance two play with more than one magnet at a time have surely noticed that each magnet has two poles, one North pole and one South pole. The North pole attracts the South pole of another magnet while the North pole repels another North pole, and the same is true for the South poles. So, we can see that there is a correlation between charges and the poles of a magnet.



The Earth can be imagined as a giant magnet, with its North pole being in the South direction, and its South pole being in the North direction.

Now, you might ask why the poles of a magnet are named as North and South poles instead of East and West. As mentioned earlier, the Earth essentially functions as a giant magnet. Therefore, if we suspend a magnet, it will align itself with the North-South direction due to the attraction of the Earth's magnetic field. The side of the magnet that faces geographical

North is called the North pole, and the side that faces South is called the South pole. Since we know that magnets attract opposite poles and repel similar poles, we can say that the South pole of the Earth's internal magnet is located in the North direction, and the North pole of the Earth magnet is located in the South direction.

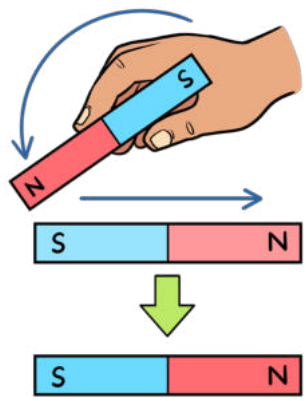
There is indeed a similarity between the attraction and repulsion of magnets and the interaction between charges, but there is a significant difference between them as well. We can keep a sphere, rod, or some other object suspended only as positively or negatively charged. However, when it comes to magnets, we cannot simply create a magnet with just a North or South pole. If is natural to think that by breaking a bar magnet in the middle you will create two magnets, one with a North pole and the other with a South pole, However, you will be surprised to find that it does not happen. Instead, the broken parts form two complete magnets with both North and South poles. If you break them again, you will see that all the broken pieces also transform into complete magnets with both poles. In this way, even if you break a magnet into infinitesimally tiny particles, each particle will still be a complete magnet, with one end being the North pole and the other end being the South pole. It is not possible to create a magnet with only one pole.

Various types of permanent magnets are created for different types of machineries and everyday use. A type of permanent magnet that humans have found in nature since ancient times is called Lodestone. Scientists theorize that these metallic ores became naturally magnetized due to lightning strikes on them. During a lightning strike, a significant amount of electricity is conducted. You will be amazed to hear that the amount of electrical energy produced by one lightning strike can power a few cities like Dhaka for a several minutes. There is a close interrelation between

electrical currents and magnetic fields, which we will discuss in this chapter.

Many many years ago, humans discovered that when a magnet is suspended, it orients itself in the north-south direction. Using this knowledge, Chinese sailors invented the first compass to determine directions almost a thousand years ago.

Those of you who have played with magnets have



If you rub an iron rod with a strong permanent magnet in the same direction repeatedly, the iron rod will transform into another permanent magnet.

surely noticed that a magnet attracts iron. Besides iron, magnets can also attract nickel and cobalt, but they do not attract materials such as copper, plastic, or aluminum. Materials that can be attracted by magnets have a special property and are called magnetic materials. If you have a comparatively strong permanent magnet, you can use it to magnetize another piece of iron or steel. To do this, you need to touch one end of the permanent magnet to the piece of iron or steel and then rub it along until you reach the end. Then, lift the permanent magnet and touch it again to the starting point and repeat, that means, the friction should always be unidirectional. By repeating this at least about twenty times, you can create a somewhat strong permanent magnet.

12.2 ELECTROMAGNETISM

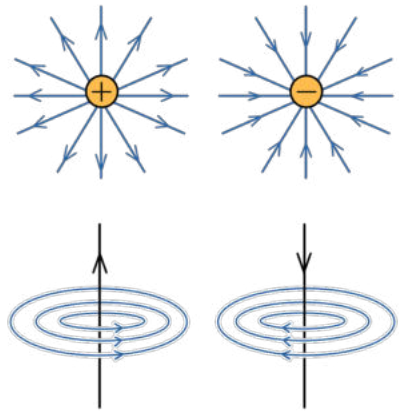
In the previous discussions, we have covered a lot about magnets, but there is still a significant question unanswered. This question pertains to the reason why specific materials possess magnetic properties—their attraction to magnets and their ability to become magnetized themselves. Examples of such materials include iron, cobalt, and nickel. Conversely, why materials like paper, wood, or plastic do not possess magnetic properties?

The reason behind these were hinted in the previous sections—the close relationship between electrical currents and magnets. In this section, we will discuss that elaborately. At first glance, it may seem that electric currents and magnetism are completely different. We use electric currents to generate light, operate fans, while use magnets to attract iron. However, in 1865 a scientist named James Clerk Maxwell showed that electricity and magnetism are the same phenomena, which is called electromagnetism. The reason behind this is quite simple: when there is an electric current, it creates a magnetic field around it. Just as a charge creates an electric field around it—that means magnetism is not a separate property; it is generated alongside electric currents. And electric current is the flow of charges. Current through electric wires happen due to the flow of electrons.

Now, you may wonder why there is a magnetic field inside a stationary magnetic needle if the magnetic field is created only due to electric current. Apparently, there is no flow of charges inside it. However, during the formation of an atom, electrons orbiting around the nucleus create a circular motion, similar to the flow of charges or electric current. This is what creates the magnetic field in permanent magnets. Not only that, each electron in an atom can be considered as tiny magnets. Electrons revolve around the nucleus and in its own axis and this motion generates a magnetic field. In other

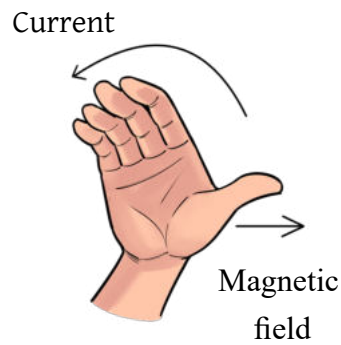
words, each atom is a tiny magnet. When these tiny magnets arrange in formation that create a strong magnetic field, we call that a permanent magnet.

Naturally, this gives rise to the question that every substance then must be a magnet because everything is made up of atoms. This is a very logical question. When you delve deeper into the structure of an atom, you will come to know that during the formation of an atom, electrons arrange themselves in their orbits in such a way that the magnetic field of one electron mostly opposes the magnetic field of the other, and they cancel each other out, leaving no remaining magnetic field. There are only a few elements whose atoms don't do that. Those substances can have a permanent magnetic field, such as iron, nickel, and cobalt.



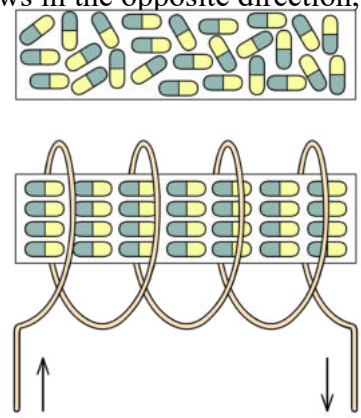
The way a charge creates an electric field around it, similarly electric current creates a magnetic field around it.

Due to electric currents, a magnetic field is created—this can be demonstrated by an experiment. Take a plastic-covered insulated wire and wrap it around a piece of drinking straw. It is necessary to wrap the wire multiple times to generate a stronger magnetic field. Now, place the wire near a compass. Naturally, the compass needle by itself will initially be aligned in the north direction. Next, touch both ends of the wire to the terminals of a battery using your fingers. You will observe that the compass needle immediately starts rotating towards the wire. The battery generates a magnetic field, which influences the compass needle to align itself in the same direction. If you reverse the direction of the current by flipping the battery, you will see that the compass needle also rotates accordingly. The right-hand rule makes it easy to determine the direction of the magnetic field when there is an electric current flowing in a certain direction. If the current flows towards the tip of the fingers, a magnetic field is



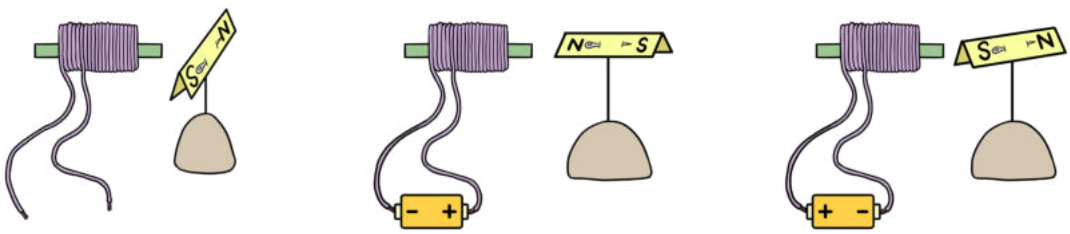
Using the right-hand rule, we can determine the direction of the magnetic field created by an electric current flowing in a certain direction.

created in the direction of the thumb. If the current flows in the opposite direction, the magnetic field is created in the opposite direction as well.



The tiny magnetic particles in a regular iron piece are randomly oriented. When electric current flows around it, these scattered particles align themselves and creates a strong magnetic field.

When an electric current flows through a wire, a magnetic field is generated. When the electric current is turned off, the magnetic field disappears, meaning we can create or eliminate a magnetic field as necessary. We can increase or decrease the magnetic field by increasing or decreasing the current. Although, a magnetic field generated only by a coil of wire in not strong enough. But we can make the magnetic field more powerful by inserting a ferromagnetic material, suchas iron, inside the coil. A simple iron rod is not a magnet itself because the tiny magnetic particles inside it are usually randomly oriented, which means no net magnetic field is created. However, if we wrap a coil of wire around the iron rod and



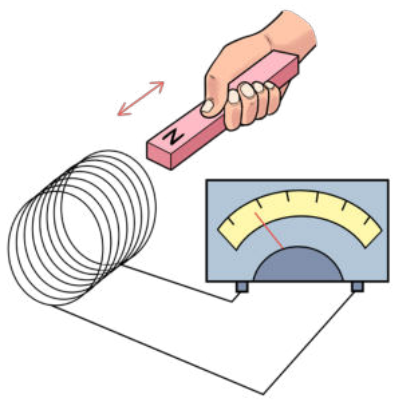
If there is an electric current through a plastic-coated wire, the magnetic field generated inside it will attract a compass towards itself. If you reverse the direction of the current, the direction of the magnetic field will also reverse.

pass an electric current through it, the magnetic domains or particles align themselves and create a consolidated magnetic field. In this way, the magnetic field of the iron rod along with the magnetic field created by the electric current combine to create a much powerful magnetic field.

12.3 ELECTROMAGNETIC INDUCTION

Magnets are a necessity for the operation of electric motors, which are used to rotate numerous devices found in our surroundings. Motors are a common example of usage of magnets. Another crucially important use of magnets is in electric generators or alternators, where electricity is produced using magnets. Scientist Oersted first demonstrated that if the magnetic field is changed inside a coil of wire, electrical power is generated within that coil.

If we connect an emitter (which can measure electric current) to both ends of an electric coil, and then introduce a magnet inside the coil, we observe that the needle of the emitter moves in one direction, indicating the presence of electric current. If the magnet is removed, the needle of the emitter moves in the opposite direction, showing the current flowing in the opposite direction. If the magnet is not in motion, there is no change in the magnetic field. Therefore, no electric current is generated. If we change the orientation of the magnet's pole and repeat the experiment, we will observe the electric current flowing in the opposite direction.



We can generate electricity by moving a magnet inside a coil of wires.

The generation of electric current in the coil by changing the magnetic field is called electromagnetic induction. This induction is used to generate electricity in electric generators.

Food for Thought: When a magnetic rod is quickly or slowly moved in-and-out of the coil of a conductor, what change do we observe in the emitter?

12.4 MAGNETIC FIELD OF EARTH

In your previous grade's chapter Structure of Earth, you learned that the internal structure of the Earth is divided into three main parts: the outer crust, the inner core, and fluid mantle surrounding the core. During the formation of the Earth, the heavier metallic elements such as iron and nickel accumulated towards the center of the Earth due to its gravitational force. The core is further divided into two parts: the solid inner core at the center and the liquid outer core. The liquid outer core circulates within

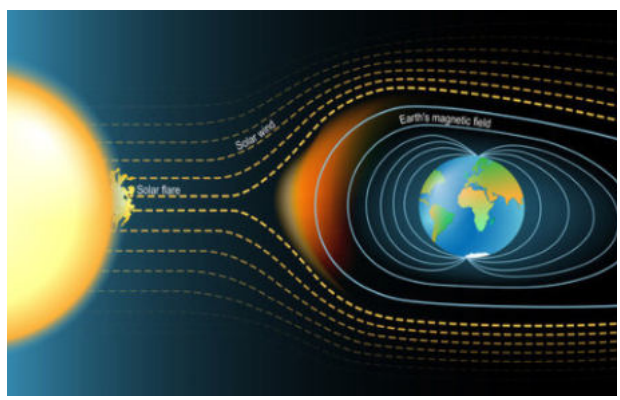
the Earth to transport heat by convection. This transport mainly involves the motion of molten metallic substances. The atoms of the molten metals are in a charged state with free electrons that creates a type of electric current. We have learned that electric current creates magnetic field. Therefore, this molten core creates a magnetic field within the Earth, which we perceive as the Earth's magnetic field or geomagnetic field.

Due to the complex nature of the Earth's interior structure, scientists have not yet fully understood the intricacies of this process, and they are continuously conducting research. Since the convection process in the mantle is not very regular, occasional changes occur in the electric current, creating changes or displacement in the resulting magnetic field. The magnetic poles are not located at the actual geographic north and south poles. The North magnetic pole is currently near Alaska and is moving towards Siberia at a rate of about 6 km per year.

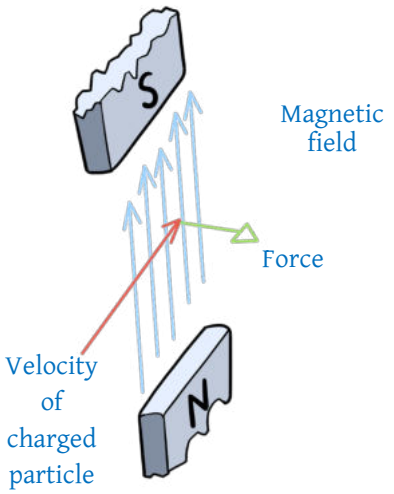
The magnetic field of Earth does not only change places around the poles, they have been found to completely reverse their positions in the Earth's history in about fifty thousand years. Scientists have determined that the Earth's magnetic field has changed direction more than a hundred times since its formation!

The Earth's magnetic field plays a crucial role in protecting the existence of life on Earth. This magnetic field surrounds and encompasses the entire Earth, starting from the North and South Magnetic Poles, and extends thousands of kilometers above the Earth's surface. This region created by the magnetic field is called the magnetosphere. Along with the light and heat we receive from the Sun, there are also harmful ultraviolet rays and occasional charged particles that come towards the Earth. The ozone layer above

the atmosphere protects us from ultraviolet rays, and the magnetosphere created by the Earth's magnetic field shields us from these ionized charged particles. The structure of the magnetosphere is influenced by the charged particles emitted from the Sun and is quite remarkable.



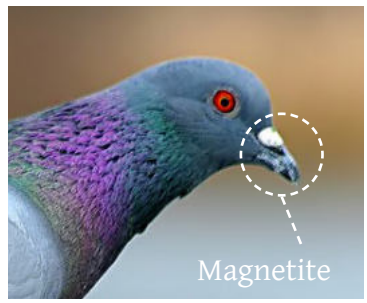
The magnetosphere created by the magnetic field of the Earth protects us from ionized charged particles that escape from the Sun.



A moving charged particle experiences a force in a magnetic field.

The region facing the Sun is compressed, while the magnetosphere extends far into space in the opposite direction. The charged particles that emanate from the Sun at high speed and approach the Earth hits the magnetic field which cause it to change direction and move away. Occasionally, some particles are trapped in the magnetic field and continue to rotate, and due to friction with the atmosphere, they become heated and emit light. The magnetic field near the Earth's north and south poles is the strongest, resulting in the concentration of such light radiation in the Polar Regions. These unique lights are known as Auroras.

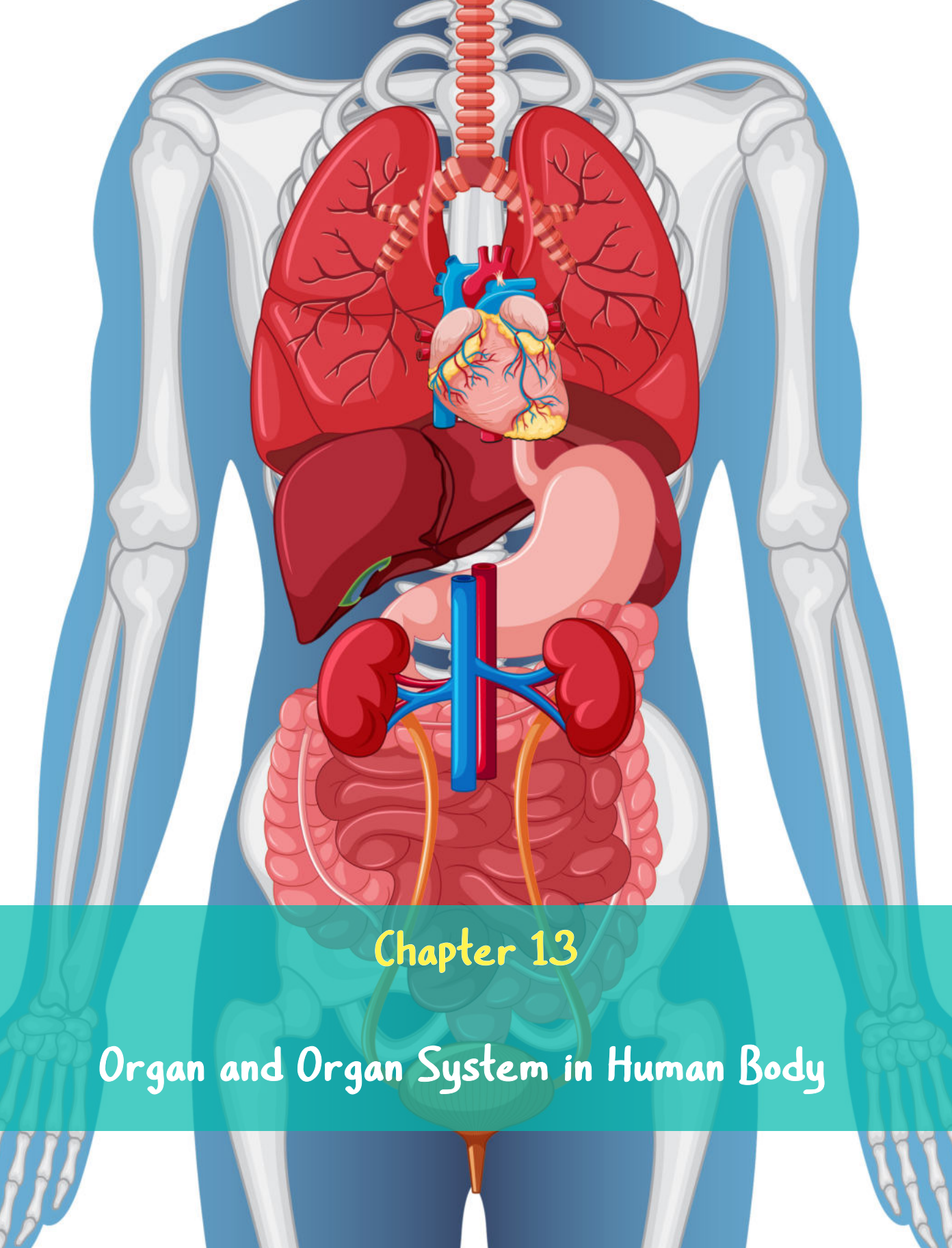
The charged particles coming from the Sun cannot penetrate the magnetic field because of another significant characteristic of the magnetic field, which is the following. If a charged particle directly approaches the magnetic field or moves parallel to it, it does not feel any force. However, if it approaches the magnetic field perpendicular to it, it experiences a force changing their motion, which deflects the charged particle sideways instead of allowing it to move straight ahead. That is why the charged particles coming from the Sun cannot penetrate the magnetic field; they get deflected to the sides. If the magnetic field becomes strong enough, the force exerted towards the side becomes so powerful that it keeps changing the direction of the charged particles, causing them to orbit around the magnetic field continuously.



It is believed that there is a special detection mechanism in the pigeon's beak for sensing magnetic fields.

Scientists create accelerators to conduct research, where electrons, protons, or charged ions are accelerated to circle in high speeds and collide with a target. Powerful magnetic fields are used to alter the trajectory of these charged particles.

It is believed that pigeons or birds have the ability to sense magnetic fields, and using the Earth's magnetic field, they can navigate in the correct direction.



Chapter 13

Organ and Organ System in Human Body

Chapter 13 Organ and Organ System in Human

This chapter deals with the following topics:

- ☑ Human body system:
- ☑ Integumentary system
- ☑ Respiratory system
- ☑ Excretory system

Organs are parts of an animal's body that are made up of one or more tissues and can perform specific functions. The branch of biology that deals with body organs is called morphology. There are two types of organs in the human body, based on where they are located. Eyes, ears, nose, hands, feet, head, these are external organs. One the other hand, stomach, duodenum, ileum, colon, heart, pancreas, spleen, lungs, kidneys, testes, and ovaries are internal organs of the human body. The branch of biology that deals with the external organs in details is called external morphology. And the branch of biology that discusses the internal organs in detail is called internal morphology or internal anatomy.

You know, various systems are formed of certain organs in the animal body to perform physiological functions such as digestion, respiration, excretion, reproduction etc. In class six, you learned about ten of such systems in the human body. You have already been told about some of these systems in your previous class. Here you will be told about Integumentary system, respiratory system, and excretory system.

13.1 Integumentary system

The outermost covering of our body is the skin. The skin shields us from injuries, bacterial attack, sunlight and heat etc. It also preserves water vapour inside our body and helps maintain our body temperature. Additionally, the skin gives us the sense of touch, and it helps us sense whether something is hot or cold.

The outer covering of our body is made up of skin, nails, hair, glands, nerves, and blood vessels inside the skin and all of these parts together form our integumentary system. The integumentary system is the largest system in the human body, and some brief

descriptions of its various organs are given below.

13.1.1 skin

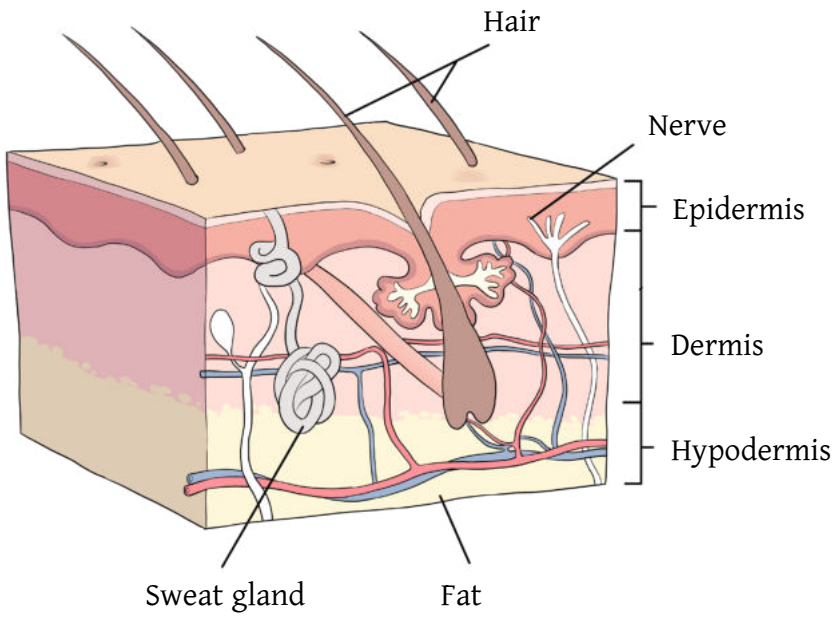
An adult human's body-skin weighs approximately three kilograms. The skin is about two millimetres thick on average. If necessary, it can be thinner in certain areas (like eyelids) and thicker in other areas (like the soles of the feet).

Human skin, also known as the dermis, is divided into three layers:

a) Epidermis: This is the topmost layer of the skin that we can see and touch. It determines our skin colour and acts as a protective waterproof coating on our body.

b) Dermis: This is the next layer of the epidermis. It is the thickest layer and contains hair follicles, sweat glands, and Sebaceous Glands

c) Hypodermis: It is the lowest layer of the skin. It is mainly made up of fat and this layer helps protect us from temperature fluctuations.



Human skin is divided into three layers

13.1.2 Nails:

Nails protect the fingers of our hands and toes. It is divided into five parts:

a) Nail plate: This is the hard and visible part of the nail.

b) Nail bed: It's the skin that covers the area under the nails.

c) Cuticle: The thin layer of skin at the base of the nail.

d) Matrix: The base of the nail that helps nails grow.

e) Lunula: The white tip of the nail is called the lunula.

13.1.3 Hair:

Hair plays a role in regulating the temperature of our head. Eyebrows and eyelashes protect our eyes from dust. Hair is made up of a protein called keratin. It is divided into three parts:

a) Hair Shaft: This is the visible part of the hair that we can see.

b) Hair follicle: It is a small tube-like structure in the skin where the hair is rooted.

c) Hair bulb: The part of the hair beneath the skin that helps the hair grow is called the hair bulb.

13.1.4 Glands:

The skin contains different glands that release watery, oily, or salty substances from within the skin onto the skin. The integumentary system consists of the following glands:

a) Sudoriferous glands: They release sweat from our body.

b) Sebaceous glands: They release oily substances from the body.

c) Ceruminous glands: They release earwax into our ears.

d) Mammary glands: These glands are found in the chest area of humans, and they produce breast milk in mothers.

13.1.5 Functions of Integumentary System:

Our skin is a crucial system in our body. It is often referred to as the body's first defence against the adverse external environment. The integumentary system shields us from microbial attacks, guards against injuries and wounds infections, and helps heal wounds. Additionally, it protects the body from the harmful ultraviolet rays of the sun.

Our skin allows us to sense pressure, heat, and other sensations, helping us take necessary actions to protect our body in dangerous situations. Skin also helps remove waste from the body through sweat, and at the same time regulates body temperature to keep us cool. Moreover, our skin stores fat, water, glucose, and produces vitamin D, which is crucial for the formation of bones in our body.

Our body is in fact a highly complex system, and all the different systems help each other to keep our body functioning.

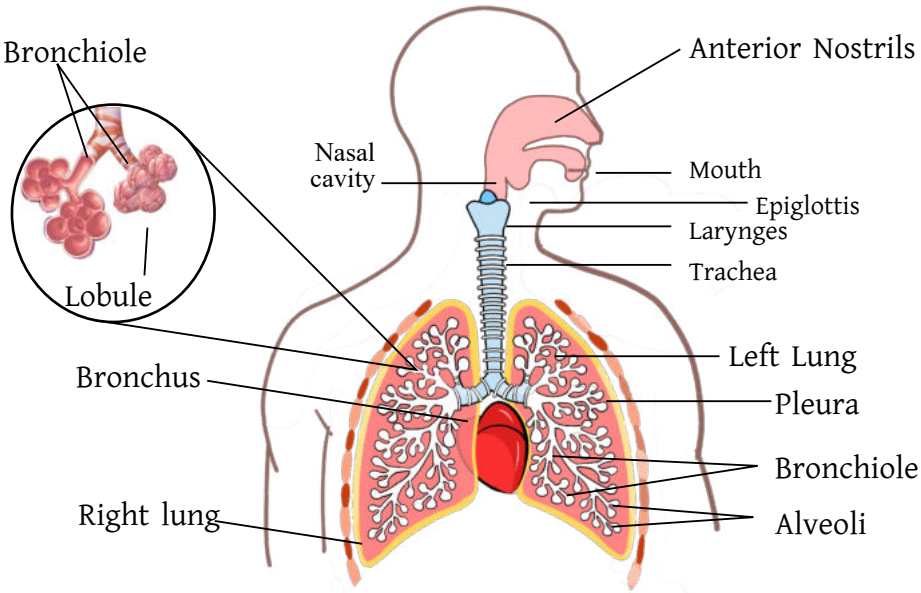
13.2 Respiratory system

No animal can live without oxygen. In our body, oxygen enters the respiratory organs with the air. It is then carried through the blood to reach the cells in all organs of our body. Food stored in the human body produces energy in oxidation process with the help of oxygen which is taken from the environment through respiratory system. This energy helps in in the daily functioning of the body.

The different parts of the human respiratory system can be divided into three zones.

13.2.1 Air intake and discharge zone

Anterior Nostrils: The two side-by-side openings at the front of the nose are called the anterior nostrils. The two anterior nostrils always remain open, and air enters the body through this passage.



The human respiratory system

Vestibule: The inner part of the nose after the nostrils is called the vestibule. The wall of the vestibule has numerous hairs. As this area is moist and the hairs act as filters, it helps to trap dust and germs from the air we breathe in.

Nasal Cavity: The part after the vestibule is the nasal cavity. The walls of the nasal cavity have cells that secrete mucus with cilia, as well as olfactory cells. This slightly

moistens the incoming air that we inhale. The ciliated and mucous cells also trap dust and harmful pathogens. The olfactory cells send the necessary stimuli to feel odour to the brain.

Nasopharynx:

The two nasal cavities open into the nasopharynx through two holes called nostrils, where air is mainly carried. The oropharynx is positioned after the nasopharynx, where both food and air are carried. Food and air split to enter the oesophagus and trachea at the end of the pharynx called the laryngopharynx.

Larynx: This is located just in front of the lower section of the pharynx and is made up of several pieces of cartilage. The thyroid cartilage is the largest of these and rises high in the front of the neck (in males). Its location is perceived with the touch of hands and is visible from the outside. This noticeable bump is called Adam's Apple. Many muscles are involved in the larynx. Its interior contains mucous membrane and vocal cord. In full stretched conditions, the vocal cord vibrates with air and produces sound.

Above the larynx, there is a small lid-shaped piece of cartilage called the epiglottis. The epiglottis close the mouth of the larynx during swallowing food so that the food cannot enter the larynx. When this process deviates, we experience hiccups. Other times it remains open for respiration.

13.2.2 Air transport zone

Windpipe/Trachea: The trachea is a hollow, cylindrical tube that extends from the larynx. It is about 12 centimetres long and has a diameter of ٢ centimetres. The trachea does not contract, allowing air to pass through it easily. The inner walls of the trachea are lined with cilia, which help prevent unwanted substances from entering.

Bronchus: The end of the trachea in the thoracic cavity is divided into two (right and left) sections, they are called bronchus (plural bronchi). The right bronchus is shorter but wider, and it splits into three smaller sections that lead to the three alveoli visible lobes of the right lung. On the other hand, the left bronchus divides into two sections that enter the two lobes of the left lung. Inside the lungs, each bronchus divides repeatedly and form numerous tiny bronchioles.

13.2.3 Respiratory zone

Lungs

We have two lungs, and they are soft, sponge-like organs that are light pink in colour.

The inside of the lungs is slippery. The left lung is smaller and has two lobes. On the other hand, the right lung is larger and has three lobes. Both lung lobes contract and expand during inhalation and exhalation. The divided bronchiole ducts are connected to the lobule, which is the functional unit of the lung. The lobules are shaped like a set of tiny balloons where oxygen taken in through respiration and carbon dioxide carried by the capillaries are exchanged. Oxygen enters the blood and carbon dioxide leaves the blood as waste and is excreted from the body through respiration.

You can see that the various organs of the respiratory system work together to ensure the supply of oxygen to our body in order to generate energy. Humans depend on the respiratory system to survive on Earth. So, we all need to try to keep the respiratory system healthy. We can keep our respiratory system healthy by not smoking, staying away from air pollution and keeping our lungs fresh by doing sports and regular exercise.

13.3 Excretory system

Excretory System

While learning about integumentary and respiratory systems in this chapter, you must have understood that waste is removed from our body through their functions. The glands of our play a role in removing waste through sweat. One of the functions of the lungs is to remove carbon dioxide as gaseous waste. That means these organs are parts of the excretory system. We will see in this chapter that the kidneys also function in a form of waste removal from the body, but these different organs of the system do not work together, each functioning more or less independently of the others. All of these organs are needed to remove all types of waste from our body completely and successfully.

Different cells in different parts of our body perform various function. During these functions, nitrogenous waste products produced inside the cells. These waste products are carried in the blood and are usually harmful to the body and therefore need to be removed from the body. In order to remove these unnecessary waste materials from the body, the excretory system is formed which consists of a pair of kidneys, a pair of ureters, a urinary bladder and a urethra.

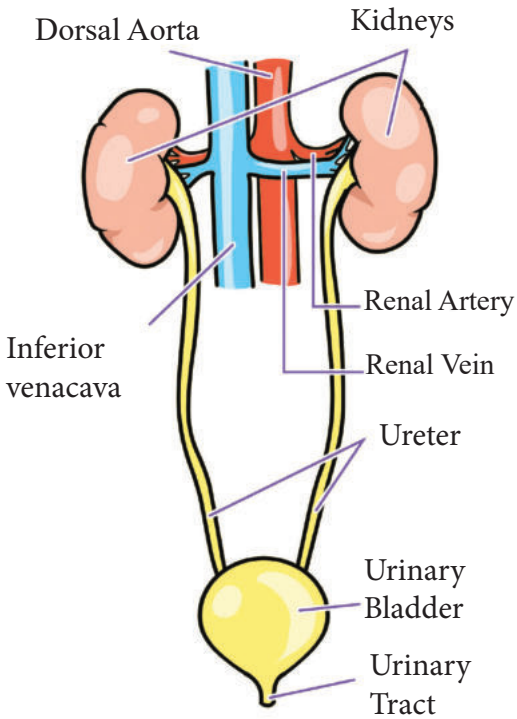
Structure of the Excretory System

Kidney: Just below the rib cage, at the back of the abdomen, on both sides of the spine, there are two kidneys. You have learned about the liver while studying the digestive

system in the previous class. The liver is quite large and is located on the right side of the abdomen. So, our right kidney is slightly lower than the left kidney. Since the kidney is the main organ of the excretory system, its structure and function are discussed in more detail below.

Ureter: The two narrow tubes that transport urine from the kidneys to the bladder are called ureters. Each ureter is approximately 25 cm long.

Urinary Bladder: The Urinary Bladder is a bag-like structure which is made of a type of involuntary muscle. The bladder can contract or flatten as needed. It can hold about 750-700 millilitres of urine. Its function is to temporarily store urine and release it at convenient times.



Structure of the Excretory System

Urethra: The tube through which urine passes from the bladder through the penis or vagina and is finally released out through an opening is called the urethra. The length of this duct in an adult male is 19-18 cm while the length of the female urethra is only 4-3 cm.

Structure and Function of Kidney

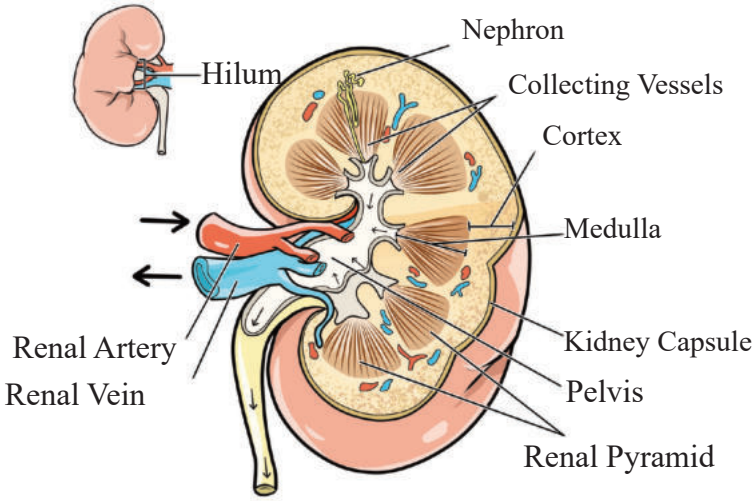
Each kidney is solid, flattened and it looks convex on the outside and concave on the inside. It is somewhat shaped like a bean seed, but not as tiny as a bean seed. A grown-up kidney is about 12-10 centimetres long, 6-5 centimetres wide, and around 3 centimetres thick. It has a darker reddish-brown colour. The concave part of the kidney is called the hilum. The renal artery enters the kidney through the hilum, while the renal vein and ureter exit from there. The entire kidney is protected by a strong covering made of fibrous connective tissue called the capsule.

The vertical section of the kidney shows three distinct parts: cortex, medulla and pelvis. The outer and relatively dark region is the cortex. Below the cortex is the medulla, which has a lighter red colour. The medulla is made up of 8-18 pyramid-shaped parts

known as renal pyramids.

Inside the kidney, the white part of the ureter extends upwards like a funnel which is called the renal pelvis.

The effective unit of blood purification in kidney is called nephron. Each kidney has around 10 lakh nephrons. The renal artery enters the kidney and splits repeated into smaller blood vessels that go into the nephron. The tiny blood filter inside the nephron which separates waste and fluid from blood is called glomerulus. The fluid that is filtered from the blood goes through a tube in the kidney called the renal tubule and undergoes absorption and secretion process several times. Eventually, it returns glucose, mineral salts, and water to the nearby blood tubes and removes only the waste products as urine.



Structure of Kidney

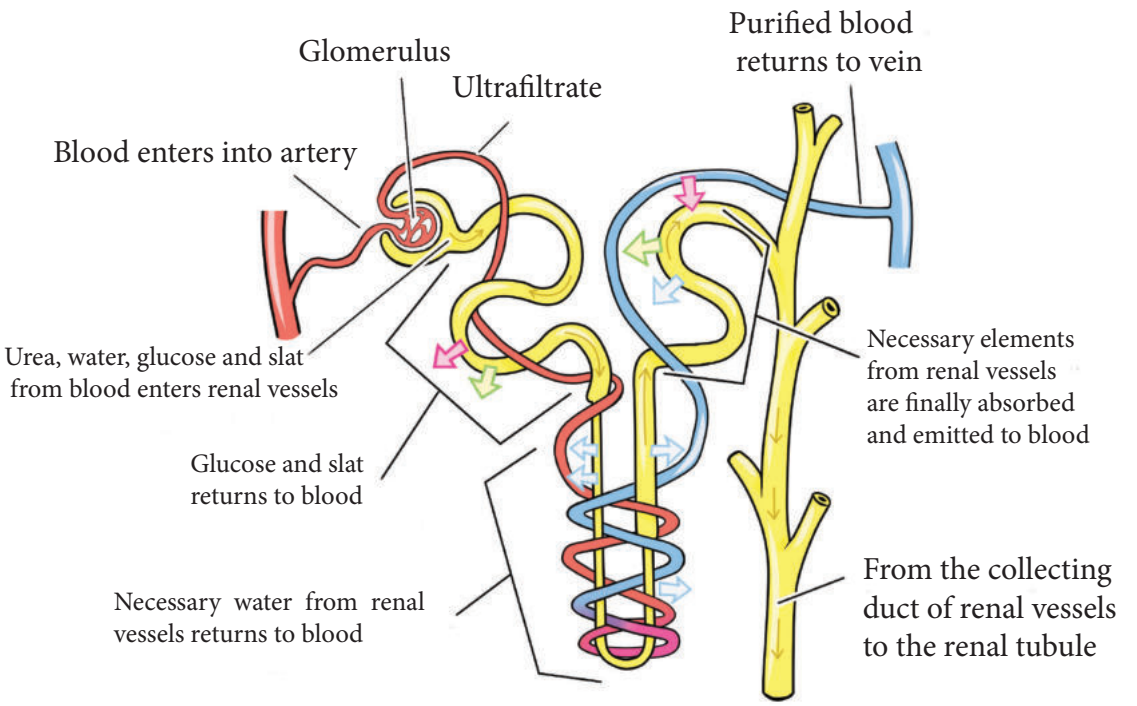
When urine is formed in the kidney, it travels through the renal pelvis and flows into the ureter. The urine flows into the bladder, due to the contraction and expansion of the involuntary muscles in the walls of the pelvis and ureter.

On the other hand, the purified blood goes back to the body through the renal veins. The kidney does an important job of cleaning about half a cup of blood every minute. This means that throughout the day, the entire blood in the body passes through the kidney several times and is cleaned.

Functions of Kidney:

You must understand that the kidney plays many important roles in our body. We can briefly explain the functions of the kidney as follows:Removes nitrogenous waste products produced as a result of protein metabolism in various cells of the body.

- Maintains the balance of water in body and blood.
- Controls the levels of sodium, potassium, calcium, phosphate, and chloride in the blood.
- Maintains the balance of acids and bases in our blood.
- Maintains the balance of various ions in the body.
- Secretes important hormones and enzymes for the body.
- Controls blood pressure.
- Removes toxins from the body that enter through food and other means.



Functions of Kidney

Chapter 14

Uses of Chemistry in Everyday Life

Chapter 14 Uses of Chemistry in Everyday Life

This chapter deals with the following topics:

- ☑ Household chemistry
- ☑ Table salt, baking powder, vinegar
- ☑ The chemistry of cleanliness and hygiene
- ☑ Cleaning techniques using soap and detergent
- ☑ Chemistry in agriculture and industry
- ☑ Chemistry in processing agricultural products
- ☑ Chemistry in preserving agricultural and food products
- ☑ Industrial waste and environmental pollution

In the previous few chapters, you have gained a basic idea of chemistry, an important branch of science. When you will learn more about chemistry, you will be surprised to realize its significance in our daily life. To give example, we use food preservatives to keep our food safe. On the other hand, different types of chemicals can sometimes make the food unsafe. Additionally, chemistry has many applications in safe drinks, various cleaning agents, cosmetics and more. You know that we use different types of fertilizers to enhance soil fertility. These fertilizers are also made up of various types of chemical substances. Moreover, the wastes produced by industries often pollute the environment. These industrial wastes are also chemical substances. Therefore, it is evident that different chemicals and chemical substances play a role in every aspect of our lives. In this chapter, we will discuss how these chemical substances are prepared, their properties and uses, and especially their impact on our lives.

14.1 Household Chemistry

Chemistry is a significant part of your daily life. We can find the presence or use of chemistry in food, air, water, life-saving medicines, cleaning chemicals and everything else we can see or touch. If we talk about food, we can see great roles of Chemistry. As for example, in this chapter, we will discuss about the chemistry of the food items-

table salt, baking soda and vinegar.

14.1.1 Food Chemistry

(a) Table Salt or Sodium Chloride (NaCl)

We know that seawater contains a significant amount of table salt or NaCl. Additionally, there are very small amounts of calcium chloride (CaCl2), magnesium chloride (MgCl2), and other salts present. In our country, we collect table salt from seawater. For example, salt is produced from seawater in various upazilas of Cox's Bazar district. Salt farmers of various upazilas of Cox's Bazar district build embankments on lands of different shapes, and leave one side slightly open.

During the time of high tide, when water enters that area, the entry point of water is closed to trap the water. When the heat of the sun causes the water in that area to evaporate, salt can be seen. The salt obtained through salt harvesting or salt farming is refined in industrial plants and converted into edible salt which is known as table salt.

Salt farming along the coastal areas

Our body needs various ions such as sodium ion (Na+), potassium ion (K+), and other ions to properly perform different functions. If there is a deficiency of sodium ion in the body, then this is where table salt (NaCl) plays a role in filling the deficiency of Na+ ions.

Uses of Sodium Chloride (NaCl):

NaCl or salt has various uses in different fields besides its food related uses. Some uses are mentioned below:

1) Salt has long been used to bring out the taste of food.

2) Salt plays an important role in food preservation, eg: salted hilsa.

3) In cooking, salt is used to raise the temperature of water.

4) Diarrhea causes dehydration in the human body. To alleviate this dehydration, oral saline is consumed. And NaCl is one of the key ingredients in preparation of oral saline.

Soda Ash or Washing Soda

5) Salt is sprinkled on the roads to melt the ice that accumulates in the cold countries.

6) In the tannery industry, salt is primarily used to preserve the collected animal skins.

7) Salt is also used in bleaching, pottery, soap and chlorine production. The salt is used in the chemical industry to prepare sodium hydroxide (NaOH) compounds. Besides, it is also widely used in other industries.

(b) Baking Soda

Baking soda is sodium bicarbonate ($NaHCO_3$) which is often known as edible soda. Baking powder is slightly different from baking soda. Baking powder contains baking soda mixed with a small amount of tartaric acid powder.

Uses of Baking Soda

There are many uses of baking soda. Some uses are mentioned below:

1) Baking powder is usually used while preparing cakes and biscuits. When baking powder is mixed with water and flour, CO_2 is produced, this CO_2 creates bubbles, causing the cake mixture to rise or swell. The baking soda ($NaHCO_3$) available in baking powder reacts with tartaric acid ($C_4H_6O_6$), and produces sodium tartrate ($C_4H_4Na_2O_6$), CO_2, and H_2O. The reaction is shown below:

$$NaHCO_3 + C_4H_6O_6 \longrightarrow C_4H_4Na_2O_6 + 2CO_2 + 2H_2O$$

If baking soda is used instead of baking powder, an acid-like ingredient must be mixed separately to make the cake swell.

2) Baking soda helps reduce acidity in the stomach. It can work as an antacid, which is used for treating stomach upset and indigestion.

3) Baking soda can be used to treat the pain of insect bites.

4) Baking soda is used for household cleaning and for deodorizing.

5) Baking soda can also function as a pesticide.

6) It is also used in ear drops, toothpaste, mouthwash and shampoo.
7) It can produce soapy foam, so it is used in fire extinguishing purposes.

(c) Vinegar

Vinegar is a liquid solution of acetic acid (CH_3COOH). Vinegar typically contains 5-10% acetic acid. Vinegar is made from the juice of different fruits, so there are many types of vinegar available in the market. Vinegar is used in food products, cleaning, personal health protection and household uses.

Uses of vinegar

1. Vinegar plays a role in food preservation. Vinegar is used to preserve the pickles. If vinegar is used in preparation of pickles, bacteria can attack it. When the acetic acid (CH_3COOH) in vinegar is added to pickles, the proton (H^+) released from the CH_3COOH can kill the bacteria. As a result, the food remains protected from bacterial attack for a longer period.

2. Vinegar is used to enhance the taste and flavor of food.

3. Vinegar is used to clean mirrors, glass or tables, to deodorize the kitchen or bathroom and to remove stains from household fabrics, carpets or sofas.

4. Vinegar solution is used to freshen up hair, skin or tired feet.

5. Vinegar can also be used to remove garden weeds.

14.1.2 Chemistry of Cleanliness:

If we want to stay healthy, there is no alternative to cleanliness and hygiene. When our

body and surroundings are clean, our mind also remains fresh. We use various types of cleaning agents to ensure cleanliness and hygiene. We use cosmetic soap to keep our body clean. To clean the clothes, we use laundry soap or soda. Bleaching powder is also used as a disinfectant. Besides, other disinfectants such as 80-95% ethanol or isopropyl alcohol are used to kill highly infectious germs like the coronavirus. Glass cleaner is used to clean glass windows and other glass products. Bathroom cleaner and toilet cleaner are used for cleaning the bathrooms and toilets. All these are made by chemical process. That is, chemistry has a very significant role in cleanliness and hygiene.

A few items related to cleanliness are discussed below.

(a) Washing Soda or Soda Ash

Sodium carbonate (Na_2CO_3) is known as soda ash. When ten molecules of water (H_2O) are chemically combined with one molecule of soda ash (Na_2CO_3), washing soda is formed. So, the chemical name of washing soda is sodium carbonate decahydrate ($Na_2CO_3.10H_2O$). Washing soda is used to deodorize, remove stains and clean clothes.

(b) Toilet Cleaner

The main ingredient in toilet cleaner is sodium hydroxide (NaOH). It is mixed with some amount of sodium hypochlorite (NaOCl). Toilet cleaner is used for cleaning toilets, commodes, etc. The surfaces of toilets, basins and commodes contain fats and proteins, various coloured organic and inorganic substances, various types of germs, etc. When toilet cleaner is used, NaOH reacts with fats and proteins, and NaOCl with coloured organic and inorganic substances, germs etc. and destroys their effectiveness.

Cleaning Technique Using Toilet Cleaner

Sodium hypochlorite (NaOCl) present in toilet cleaner reacts with water to produce sodium hypochlorous acid (HOCl) and sodium hydroxide (NaOH).

$$NaOCl + H_2O \rightleftharpoons NaOH + HOCl$$

Sodium hydroxide helps to clean fat and protein substances, because it is alkaline. On the other hand, hypochlorous acid (HOCl) decomposes to form hydrochloric acid (HCl) and stagnant oxygen [O]. (Oxygen is represented by [O] in the third bracket)

$$HOCl + H_2O \rightarrow HCl + [O]$$

This stagnant oxygen bleaches or decolourizes the coloured substances and also kills the germs. In this way, the toilet cleaner works to clean the toilet by decolorizing the coloured substances and destroying the germs.

(c) Soap

Sodium stearate or potassium stearate is the chemical name for soap. The formula for sodium stearate is $C_{17}H_{35}COONa$, and the formula for potassium stearate is $C_{17}H_{35}COOK$. Soap is produced by the reaction of NaOH or KOH with fats or oils. This process of producing soap is called saponification.

Based on usage, soaps can be divided into two categories:

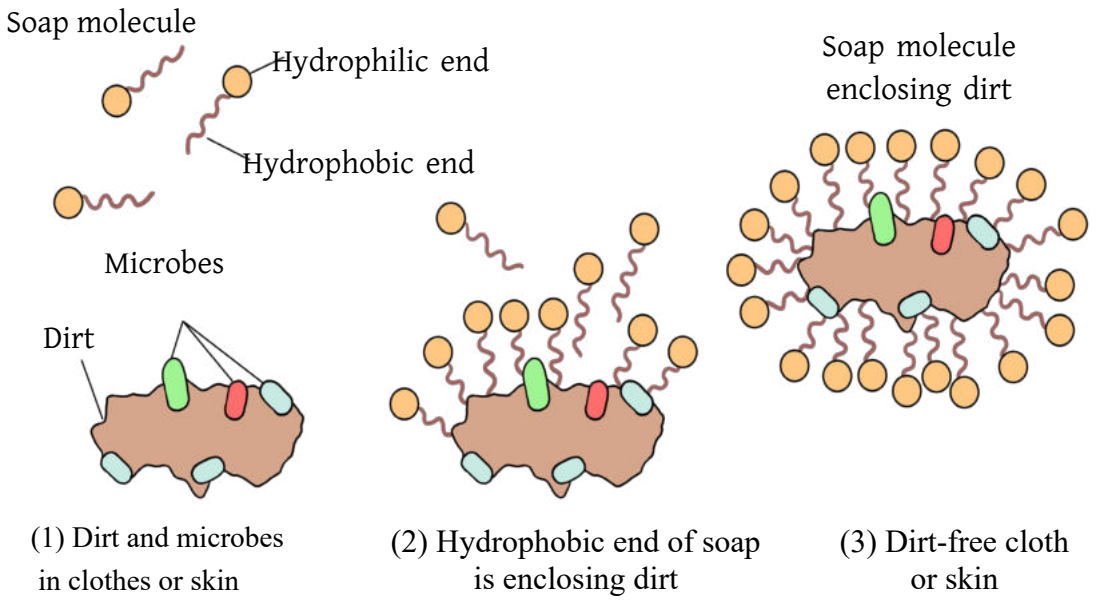
1) Cosmetic soap and 2) Laundry soap. Cosmetic soaps are used for bathing, washing hands and face, or cleansing the skin. On the other hand, the soaps that we use to wash or clean clothes are called laundry soaps.

(d) Detergent

Soaps are made with natural ingredients. On the other hand, detergents are made artificially through chemical processes. Sodium lauryl sulfate ($C_{12}H_{25}SO_4Na$) is one of the main chemical ingredients in detergents. Just like soap, detergent is a type of cleaning chemical. Detergent is available in both liquid and powder forms in the market. Various substances are added to detergent to make it usable. Therefore, although detergents are very effective as cleaning agents, they are not as environmentally friendly as soaps.

Cleansing Mechanism of Soap:

All the dirt that sticks to the clothes or our skin is organic substance and insoluble in water. Therefore, simply washing with water cannot clean this dirt. Soap ($C_{17}H_{35}COONa$) is a molecule with long carbon chains. When dissolved in water, they divide into negatively charged $C_{17}H_{35}COO^-$ ions and positively charged Na^+. Since the negatively charged end of the soap ion attracts water, this end is called the hydrophilic or water-attracting end. The other end of the soap ion dissolves in oil or grease and this end is called hydrophobic or water-repellent.When soap, in the presence of water, comes in contact with oil or grease laden dirt on clothes, the hydrophobic ends are attracted to the oil or grease and dissolve in it. On the other hand, the hydrophilic end is attracted to water, and the oil-like dirt particles are surrounded by the charged ions of the soap or detergent, forming a ring around the dirt particles. In this condition, when the cloth is rubbed or twisted for washing, the dirt particles are released. This is how soap or detergent cleans dirt or germs from clothes or skin.



Cleansing mechanism with soap and detergent

Precautions in using excessive soap or detergent:

During the preparation of soap, some amount of alkali remains in the soap. As a result, excessive use of soap can harm the skin of the hand. Again, when soap or detergent is used on the banks of ponds, lakes, or rivers, the foam produced by the soap and detergent mixes with the water. This foam reacts with dissolved oxygen in the water, and reduces the amount of dissolved oxygen. As a result, aquatic plants and fish living in the water die. This is how water is polluted for the excessive use of soap and detergent.

Precautions in using cosmetics:

We use various cosmetic products like soap, shampoo, cream, etc., to keep our skin clean, maintain the beauty of the skin, cleanse our hair, and for various other purposes. Since our skin is naturally acidic, it can very often protect the skin from bacterial attacks or infections. Therefore, if cosmetic products contain excessive alkaline substances they can reduce the natural acidity of the skin. As a result, the beauty of the skin can be lost, and the chances of being infected by germs may also increase.

(e) Bleaching powder

The chemical name of bleaching powder is calcium hypochlorite ($Ca(OCl)_2$). When clothes or any other fabric gets stained with ballpoint ink or any other colour, which cannot be removed by using soap or detergent, bleaching powder can be used to clean them. Moreover, bleaching powder is also used to disinfect floors, basins, and other places. Again, bleaching powder is used to disinfect swimming pool water or purify drinking water.

14.2 Chemistry in Agriculture and Industry

Chemistry plays an important role in agriculture and industry. In both fields, chemistry strives to improve our standard of life by innovations.

The use of chemical fertilizers in agriculture has played a significant role in crop production. These fertilizers supply the necessary nutrients to crops and increase their yields manifold. Along with fertilizers, chemical pesticides protect crops from pests, diseases, and weeds. Through chemical processes, soil analysis helps farmers determine which crops can be grown in which soil and what type of fertilizer should be used. This assists farmers in making right decisions. With the help of chemistry, the necessary safe measures are taken to preserve various agricultural crops and fruits. Moreover, the nutritional value of agricultural food is determined by the chemistry of food.

Different industries and factories require different types of chemical products. The chemical industry depends on chemistry to produce these chemical products. This industry produces raw materials for other industries such as glass, pharmaceuticals, plastics, and much more. Chemistry plays a significant role in the development of new advanced materials like various polymers, composites, and nanomaterials. Currently, the dependency on batteries and fuel cells has increased significantly due to the importance given to renewable energy, and these industries almost entirely depend on the chemical industry. The industry that needs to be mentioned separately on the basis of chemistry is the pharmaceutical industry. This industry has been continuously discovering new drugs and vaccines which are essential for treating diseases and improving public health.

So, in a nutshell, the contribution of chemistry in the development of agriculture and industry is incomparable.

Chemical Substances in the Processing and Preservation of Agricultural Products:

The process in which chemical substances are used to preserve or prevent from rotting of the agricultural products (such as fruits, vegetables, fish, etc.) for a long time is called agricultural processing. Agricultural products are preserved by using ice, table

salt, vinegar, etc. to prevent bad smell and spoilage. For example, we use ice to preserve fish, preserve potatoes in cold storage. Similarly, vinegar is used to store tomatoes, raw mangoes, and other items in containers for a long time.

It is to be noted that food products should not be preserved with formalin. Formalin can be harmful to humans and other animals, and even cause death if formalin enters our bodies.

Food Preservative:

Some chemical substances are often added to food to prevent the growth of bacteria, bad smell, spoilage. These chemical substances are called food preservatives. Some food preservatives are approved by the World Health Organization (WHO). Food preservatives that do not cause harm to our bodies and have been approved by the WHO as food preservatives are known as approved food preservatives. For example, sodium benzoate, vinegar, salt solution, etc. are approved food preservatives. On the other hand, food preservatives that can cause harm to our bodies when they enter our bodies are called unapproved food preservatives. For example, Formaldehyde or formalin.

14.3 Industrial Waste and Environmental Pollution:

Various types of wastes are discharged from industrial factories. If this waste is released directly into the environment without proper management, it can pollute the environment.

The waste materials that are disposed of from factories can be of three types: solid, liquid, or gaseous. Among solid wastes, there are metallic particles, plastics, paper, discarded electronic circuit boards, cardboard, etc. Liquid wastes include toxic chemicals, metallic solutions, acids, alkalis etc. Gaseous wastes include various acidic gases, greenhouse gases, biodegradable materials, smoke, toxic gases, and more. Moreover, without proper management, medical waste, radioactive waste, or organic waste can create dangerous environmental conditions.

If industrial waste is not managed properly, it can cause soil, water, or air pollution in a large geographical area. When the soil becomes contaminated with toxic chemicals, it affects the crops in the area and eventually enters the human body through food. Water pollution harms aquatic plants and animals, and people become victims of this pollution by consuming fish as part of their food. Due to air pollution, people all over the world are suffering from various respiratory diseases.

Environmental pollution is not limited to just a single area, but it also has an adverse impact on the climate as a whole. Therefore, it is very important to have state regulations

on the mismanagement of industrial waste. For this purpose, there is no alternative to public awareness and collective initiatives for sustainable solutions.

In our country, leather industry, dyeing industry, pesticide industry, etc. release waste materials into the environment, containing heavy metals such as chromium (Cr), lead (Pb), mercury (Hg), cadmium (Cd), etc. In many places, these waste materials have entered the soil and water due to improper processing. When we cultivate crops or when plants grow in such soil, these heavy metals enter the plants. If we eat fruits from these plants, these heavy metals can enter our bodies as well. As a result, they can cause damage to our kidneys, liver, and even lead to death.

Similarly, we indiscriminately dispose of polythene and plastic materials everywhere. They mix in the water of ponds, rivers, various water bodies, and even the ocean, turning into tiny particles. These tiny particles are called microplastics. These microplastics also enter the fish that live in ponds, rivers, water bodies and seawater. When we eat these fish, microplastics can also enter our bodies, causing various physical problems.

Therefore, protecting our country from environmental pollution has now become one of our most important responsibilities.

Chapter 15

Renewable and Non-renewable Resources

Chapter 15 Renewable and Non-renewable Resources

This chapter deals with the following topics:

- ☑ Resources
- ☑ General idea
- ☑ Types of assets on various bases
- ☑ Characteristics of renewable and non-renewable resources and their differences
- ☑ Generation process, timing and availability of renewable and non-renewable resources
- ☑ Source and use of resources: renewable and non-renewable resources
- ☑ Water management: types of usable water, use of water in different fields, availability of water

15.1 Resources

What do we mean by resources? Everything that humans need for their lives- starting from basic living to living a better life is considered as resources. That's why, education, knowledge, skills, and experiences of human beings are also regarded as resources. That's why, we call skilled people as human resources. However, in this chapter, we will discuss only natural resources.

We obtain metals like iron, copper, aluminum, as well as water, air, sunlight, soil from nature. So, they are all natural resources. We use various natural resources such as wood, gas, coal as sources of energy. Also, a variety of resources are used in the production of different materials. For example, the metal used in the construction of various types of vehicle structures and parts are obtained by extracting from ores collected from mines. The rubber used in car tires comes from processing the gum which is collected from rubber trees. The wood of the pencil with which you write or draw comes from a cedar or poplar tree. Graphite (a type of carbon), one of the components for making pencil leads, is obtained from mining. The water in which we clean clothes and let them dry in sunlight and air are also resources. In fact, these are all natural resources because their

source is nature, and there is a demand for them in human life.

An important characteristic of resource is its renewability — that is, whether a resource can be naturally replenished after its use. On the basis of this, resources can be divided into two categories: renewable resources and non-renewable resources.

15.2 Renewable Resources

Renewable resources are those resources that can be naturally replenished or reproduced within the lifespan of human beings. That's why, renewable resources are always considered as sustainable and environment-friendly alternatives to non-renewable resources.

15.2.1 Characteristics of Renewable Resources:

The three main characteristics of renewable resources are abundance, reproducibility and no adverse impact on the environment.

Abundance: Renewable resources are abundant, and there is no possibility of running out of use. For example, as long as the sun continues to illuminate the Earth, we will have access to solar energy, and there is no possibility of running out even within trillions of years.

(a) Solar panel (b) Solar power tower or solar concentrator situated in Spain. Here the heat energy of the sun is condensed and utilized by using curved mirrors.

Ability to Regenerate: Renewable resources often have the ability to regenerate. For example, if we collect firewood by cutting branches from a tree, new branches will grow on the tree. Forests also have the ability to regenerate. If we harvest a limited amount of resources from the forest, it is replenished over time. In 2007, the devastating cyclone Sidr caused significant damage to the Sundarbans. Following the advice of experts, the people were advised to refrain from collecting fallen and damaged trees from forests. As a result, within just five to six years, the damaged regions of the

Sundarbans returned to their previous state.

Minimal Adverse Impact on the Environment: The most important characteristic of renewable resources is that they have very minimal adverse impact on the environment—they often do not have any significant impact at all. For example, using solar energy, heat, or wind energy does not have any adverse effect on the environment.

15.2.2 Examples of Renewable Resources:

There are various types of renewable resources. Some of them fulfill our energy needs, while some others meet our material needs. Some of the notable renewable resources are mentioned below:

Solar Power: Through the process of nuclear reactions called fusion within the Sun, an enormous amount of energy is generated. This solar energy emitted from the Sun reaches the Earth in the form of heat and light. Solar energy has a huge potential as a source of heat and for electricity generation. All of you have seen the direct conversion of sunlight into electricity with photovoltaic panels or solar panels. Large solar concentrators are used to generate steam for various purposes. In the cold countries, solar energy can be used to heat water and keep houses warm in winter.

Wind Power: Humans have been using wind power since ancient times. Even a few days ago, in our country, there was a familiar sight of sailboats on the rivers that could transport a large amount of goods without the use of any fuel or human labour. The power of wind can be utilized to generate electricity through wind turbines. Countries like Denmark, Uruguay, China, Lithuania, and Germany have progressed a lot in the field of electricity generation by utilizing wind power. In Bangladesh, the generation of electricity from wind power has begun in Cox's Bazar and Kutubdia. Wind power does not release any pollutant into the environment. That's why it is a clean source of energy. Besides, there is no risk of wind power to run out, and it is widely applicable.

Sailboat

Hydropower: Hydroelectric power plants utilize the pressure of water flow in large reservoirs to generate electricity. In Kaptai in Rangamati district of Bangladesh, there

is a hydroelectric power plant that plays a significant role in fulfilling the country's electricity demands. Although not indefinitely like solar or wind power, a hydroelectric power plant can supply electricity for many years. There are a large number of hydroelectric power plants in different countries of the world.

Biomass: Biomass refers to various organic materials, such as poultry waste, kitchen waste, livestock waste, other agricultural wastes, wood etc. Through the process of decomposition, many of these wastes can be used for heat and power generation, and some can be used directly. Using biogas plants, fuel gas as well as fertile organic fertilizers can be found, and can later be used on agricultural lands. Organic fertilizers are eco-friendly and do not pollute like chemical fertilizers. As humans and other animals continuously produce organic wastes, biomass is considered a renewable resource.

Forests: Due to various geographical and climatic factors, different types of forests have formed in various parts of the world. These forests provide a huge portion of the necessary oxygen for the respiration of humans and all living beings on Earth. Many resources that are necessary for humans are also collected from forests. If forest resources are collected following appropriate rules, forests naturally replenish them over time.

Geothermal Energy: The deeper we go into the Earth's surface, the higher the temperature becomes. This heat energy can be utilized to generate electrical energy. To do this, water is pumped underground using pipes, where the water turns into steam due to the underground temperature. Then the steam is brought to the surface through another pipe to be used for various purposes. Countries that have volcanoes or heat at a shallow depth from the surface have good opportunities to utilize geothermal energy. Countries like Iceland, New Zealand, Indonesia, the Philippines, Italy etc. can easily utilize geothermal energy. In Iceland, 90% of heat demand is supplied

A traditional windmill used in a village in the Netherlands and a modern windmill

from geothermal energy. Geothermal energy production does not cause environmental pollution. Besides, it is nearly limitless in its availability.

15.2.3 Advantages and Disadvantages of Renewable Resources:

Renewable resources generally emit less greenhouse gases, and even if they do, it is minimal. As a result, the use of renewable resources does not adversely affect climate change. As they can be replenished naturally or with the help of human technology, there is the assurance of long-term availability of these resources. It is possible to reduce dependence on single energy sources by the mixed use of renewable resources. For example, where solar or hydroelectric power is readily available, there is little or, in many cases, no need to use fossil fuels.

Amazon has the largest forest area in the world.

However, there are some limitations in the use of renewable resources. It is not always possible to collect solar and wind energy. Solar energy is not available on cloudy days or at night. So, the electricity generated from solar energy is to be stored. But, the technology for efficient energy storage through batteries is complex and costly. In addition, existing infrastructures are mainly based on using non-renewable resources. Therefore, the development of new infrastructure for the use of renewable resources is time-consuming. Moreover, its use is also somewhat difficult and often requires the development of new technologies. The initial investment to install renewable energy infrastructure is high, although that cost will be gradually

The waste management plant at Jessore produces biogas, compost and electricity.

decreasing over time. In addition, it is essential to ensure coordination among all types of renewable resources, so that the absence of one can be covered by the availability of another when necessary.

Geothermal power plant located in the Philippines

15.3 Non-renewable Resources

Non-renewable resources are limited in quantity and have formed over millions of years through geological processes. Once they are used, they cannot be replenished within the human lifetime. Among non-renewable resources are fossil fuels, mineral resources, nuclear fuel, etc. Besides, various valuable substances or materials also fall under non-renewable resources.

15.3.1 Examples of Non-renewable Resources:

Some of the important non-renewable resources are mentioned below.

Fossil Fuels: Fossil fuels refer to coal, oil, and natural gas, and these are the primary sources of global energy. For trillions of years, the remains of various plants and animals have been buried under layers of soil and rocks, and transformed into different forms of fossil fuels. These fossil fuels have powered industrialization and transportation for several centuries. We travel in CNG autorickshaws, and that CNG (Compressed Natural Gas) is actually prepared from natural gas. In addition, the buses and trains that we travel on are primarily powered by diesel. Many of the power plants we get our electricity from also run on coal. All of these are non-renewable resources.

Minerals and Metals: Metals such as iron, copper, aluminium, etc., are extracted from various types of mineral ores. In addition, precious metals such as gold, silver, platinum, and diamonds are also extracted from mines. These are non-renewable resources. Their deposits are limited and cannot be replenished once they are collected.

Nuclear Fuel: Nuclear fuel, especially uranium, plays an important role in the production of nuclear energy. Uranium is split in nuclear power plants to generate large amounts of energy, which is then used to generate electricity. However, special precautions are required for the extraction and management of this nuclear fuel.

Uranium is extracted from some ores (such as pitchblende).

15.3.2 Advantages and Disadvantages of Non-renewable Resources

Non-renewable resources can be used immediately. One of the main advantages of using these resources is their energy density, that means, a small amount of resource contains a lot of energy, and it is easy to produce or transport. In addition, non-renewable resources can be produced and used at a low cost using existing technologies. This is why they are often used.

On the other hand, the extraction, processing, and combustion or burning of non-renewable resources can cause various types of environmental problems. Indiscriminate use of non-renewable resources plays a major role in environmental degradation, air pollution and climate change. Moreover, non-renewable resources are limited, so their overuse can lead to a shortage of these resources for future generations.

Both renewable and non-renewable resources are extremely important for sustainable development. By using renewable resources and implementing responsible non-renewable resource management, we can ensure the security of resources and environment for future generations.

Iron ore extracted from mines (which is a non-renewable resource) is used to produce steel.

15.4 Resources and Waste

One of the major limitations of resource use is that they produce waste. However, this waste is mainly produced from non-renewable resources. For example, glass is produced from glass sand, and this glass is used to produce various utensils that we use for our daily needs. But when a glass product breaks, it immediately becomes an unnecessary waste. Plastic bottles and various tools are made from hydrocarbons. But when they are no longer in use, they become waste, such as plastic water bottles. Again, old paper, clothes, etc. that we throw away are also wastes. Again, we throw away old paper, clothes, etc., which are also waste. The waste produced in the kitchen is perishable. If it is not removed quickly and properly, it can pollute the environment.

Waste is harmful to the environment. However, by following some methods, we can

reduce the amount of waste and use less amount of resources at the same time. In this case, three Rs are followed (RRR). RRR stands for Reduce, Reuse, and Recycle. We can prevent wastage and reduce consumption by using water, gas, and electricity carefully. After the main work is done, we can also use glass or plastic bottles for other purposes. On the other hand, materials that can be processed and reused can be used as raw materials for making new products. Paper, broken glass, metal, or plastic are such recyclable materials.

Question: Can you create any Bangla word similar to RRR in English that has a specific meaning?

15.5 Water Management

Water is an extremely important resource in our daily lives. Three-fourths of the Earth's surface is covered by oceans. Even then, less than 1% of the Earth's total water is usable for us. Of this 1% usable water, 70% is used in agriculture, 20% in industry, and the remaining 10% in household activities. Water is a renewable resource, but it can become non-renewable due to overuse, waste, or pollution. Due to the high demand for water on the Earth, water management is essential.

15.5.1. Types of usable water

Around 97% of the water on Earth is in the oceans and seas, and it is salt water. On the other hand, only 3% of the water on Earth is fresh water. Of this fresh water, only 1% is on the surface in rivers, lakes, or water bodies. The remaining portion is underground, in glaciers, or in ice caps on the mountains. Fresh water sources, such as rivers, lakes, water bodies, and groundwater have a very low concentration of salt. So, they are essential for human use and various activities. Groundwater stored beneath the Earth's surface is a significant source of water for agriculture and drinking water. Deep and shallow wells and tube wells are used to extract groundwater. The surface water of rivers, lakes, and water bodies is used for irrigation, fish farming or pisciculture, transportation, industrial processes, and recreational activities. On the other hand, seawater is salty and it is necessary to remove salt from it to directly use it or to make it suitable for other uses. However, this process is expensive.

15.5.2. Use of Water in Different Fields or Purposes

Agriculture: Water is essential for irrigation in agricultural land, animal husbandry, and pisciculture, and thus it ensures our food production and helps us earn livelihoods.

Domestic use: Water is essential for drinking, cooking, cleaning, sanitation, good

health and public health.

Industry: Water is extensively used in the industrial sector for production processes, cooling systems of various machines, and power generation.
Power Generation: Water is very essential for hydroelectric power generation, cooling systems in thermal power plants or in nuclear reactors.
Environment and Ecosystems: Water supports various ecosystems, wildlife habitats, and environmental processes, as well as ensures biodiversity and ecological balance.

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Environment and Ecosystems: Water supports various ecosystems, wildlife habitats, and environmental processes, as well as ensures biodiversity and ecological balance.

15.5.3. Availability and Limitations of Water

The availability of water is not equal all over the world. While Bangladesh is blessed with hundreds of rivers, there are many regions in the world that are deserts and where availability of water is very low. Again, in some areas there is an adequate water supply, but the quantity of usable water is limited. In some areas, there is a water shortage due to higher demand than the supply. When the supply of water in an area is less than the demand, it creates pressure on the water resources. As a result, it affects the people and environment in those areas. Consequently, this can sometimes lead to social unrest or even national conflicts.
When excessive groundwater is extracted from a location, the groundwater level is lowered. As a result, it becomes difficult to collect water from the previous wells or tube wells. In coastal areas, excessive groundwater extraction can lead seawater to enter groundwater, making it salty. Salty water cannot be used directly for most of the purposes. Population growth and rapid urbanization create pressure on water resources. Therefore, effective water management is essential in urban areas.
In recent times, climate change, changing rainfall patterns, prolonged droughts, and changes in the water cycle have begun to affect water availability, increasing

water scarcity. It has created new pressures on our social and national life.

15.5.4. Water Management Strategies

Effective water management is essential for sustainable water use. Proper water conservation measures help reduce water waste. This requires efficient irrigation systems, water conservation technologies, as well as public awareness campaigns. Polluted water can be purified and used for agriculture, industry, and environmental development, and thus pressure on clean water resources can be reduced. Rainwater collection and storage can also be used as an additional source of water. This method is especially effective in the areas with limited water resources.

In conclusion, it is very important to run water management effectively by considering different types, uses, and availability of water in order to ensure sustainable water use and safe water supplies in the future.

97% of the Earth's water is in oceans, 2% in glaciers, ice caps or underground, and only 1% is in rivers, lakes or water bodies.

Chapter 16

Natural Resources of Bangladesh

Chapter 16 Natural Resources of Bangladesh

This chapter deals with the following topics:

- ☑ Natural resources of Bangladesh: definition, types
- ☑ Mineral resources of Bangladesh
- ☑ Ore mineral resources
- ☑ Energy mineral resources
- ☑ Impact on the environment due to the extraction of natural resources
- ☑ Precautions in using natural resources
- ☑ Renewability
- ☑ Constraints on resource availability

Bangladesh is a small but densely populated country located in South Asia. It possesses various natural resources. Its geographical location with the Ganga-Brahmaputra / Ganges-Brahmaputra delta system and the Bay of Bengal is one of the reasons for the availability of country's natural resources including fertile land, rivers, forests and minerals. The country is renowned for its fertile agricultural land, which is the primary source of livelihood for the majority of its population. Bangladesh is also rich in mineral resources like natural gas, coal, and oil. The coastal areas of the country are habitats for various marine resources, including fish, shrimp, and crabs, which play an important role in the country's fisheries industry. The natural resources of Bangladesh are a crucial component for achieving sustainable development of the country.

16.1 Natural Resources of Bangladesh

Natural resources refer to all the elements or substances that originate from the natural environment and possess economic value. Air, water, soil, minerals, forests, wildlife, and fossil fuels are some examples of natural resources. These resources can be either renewable or non-renewable. Natural resources play an important role in sustaining life on Earth and are essential for human economic activities like food production, energy generation, and industrial production.

Different types of natural resources are found in different parts of the world, but they are not equally distributed everywhere. Some places have more resources, while others have less. It is very important to ensure the conservation of resources in regions or countries where resources are scarce. Bangladesh also has various natural resources, but the quantity of many of them is much lower compared to the country's needs. Therefore, we must use these resources calculatedly.

The natural resources of Bangladesh can be divided into several categories, such as agricultural resources, forest resources, fisheries resources, mineral resources, land, water, and so on. Agricultural resources play a role in economic development along with food production. Fisheries resources fulfill a large part of the country's demand for protein. From mineral resources, we get raw materials for fuel and industrial production. This chapter mainly focuses on the mineral resources, forest resources, and water resources of Bangladesh.

16.2 Mineral Resources of Bangladesh

Mineral substances are those chemical compounds that are formed naturally, either from one or more elements, or by slight modification, and are found in rock layers. Different rock components gradually transform into different minerals through various chemical processes over geological time. Among the mentionable mineral resources on Earth are natural gas, mineral oil, coal, iron ore, aluminum, gold, diamond, tungsten, limestone, glass sand, porcelain, copper, solid rock, etc.

Although Bangladesh is not rich enough in mineral resources, several minerals are available in this country. Among them are natural gas, mineral oil, glass sand, coal, limestone, solid rock, porcelain, gravel, heavy metal-bearing sands, uranium ore, iron, etc. The mineral resources of Bangladesh can be primarily divided into (1) energy resources, and (2) ores and other mineral resources. Among these resources, some of the commercially important resources are discussed below.

16.2.1 Energy Resources

Among the energy resources of Bangladesh obtained from mines, there are coal, natural gas, and mineral oil. These minerals are used as sources of energy in various industries and factories. In various thermal power plants, electricity is generated from coal and gas, and supplied throughout the country.

Coal: The coal obtained in Bangladesh is primarily bituminous, lignite, and peat type. Among the coals obtained in Bangladesh, superior quality coals are bituminous and lignite and which contains 60% to 50% of the fuel carbon. On the other hand, though

peat is not exactly coal, it is known as peat coal, with only 30% to 40% carbon fuel content.So far, a total of five coalfields have been discovered in the country. Among them, the first discovered coal mine is located in Jamalganj of Joypurhat district. In spite of being the largest coal mine in terms of deposits, coal extraction has not yet started from this mine as it is much deeper from the surface. However, a large amount of coal is produced from the Barapukuria coalfield in Dinajpur most of which is used in Barapukuria thermal power plant for power generation. Three other coalfields are at Dighipara and Phulbari in Dinajpur district, and Khalaspir in Rangpur district. Besides these coalfields, bituminous and lignite coal deposits of high-quality have been found in Rajshahi, Dinajpur, Bogra, Naogaon, and Sylhet districts.

A significant amount of peat deposits has been found in various regions of Moulvibazar, Sunamganj, Madaripur and Khulna in Bangladesh. Trees and shrubs need to be under heat and pressure beneath the soil for millions of years in order to form actual coal, though for peat, it takes several thousand years. The colour of the peat obtained in Bangladesh is brown to dark brown. Due to the proximity of the peat fields to the earth's surface, in Bangladesh they can be easily extracted. Peat is commonly used as fuel in brick fields, boilers, and sometimes even for household purposes.

Natural Gas: Natural gas is an important source of energy resources in Bangladesh. Natural gas is basically a mixture of methane, propane, butane and other hydrocarbon gases. So far, a total of 29 gas fields have been discovered in Bangladesh, and there is possibility of more gas fields to be discovered. Among them, gas production is going on from some gas fields, some are suspended and some are yet to start gas production. Active gas fields in Bangladesh include Titas, Habiganj, Bakhrabad, Kailastila, Rashidpur, Haripur etc. The extracted gas from the Titas Gas Field is used in fertilizer factory and thermal power plant in Ashuganj and Ghodarashal, as well as in the Siddhirganj thermal power plant.

The natural gas obtained in Bangladesh is of very high quality and contains very little water vapor or impurities, with a high amount of methane (96-99%). Natural gas fulfills approximately 71% of the country's total commercial fuel consumption. The gas that is supplied to households through pipelines or cylinders for household cooking purpose is produced by purifying natural gas.

Mineral Oil: In 1986, the country's only mineral oil field was discovered in Haripur, Sylhet. About 60% of the total deposit of oil in this oil field has been extracted. Production was stopped in early 1994 after oil production declined. According to

experts, with proper management of evaluation, it may be possible to achieve full-scale oil production.

16.2.2 Ore and Other Mineral Resources

Bangladesh is a densely populated country and, it does not have sufficient mineral resources, compared to its demand. For this reason, various types of mineral resources are imported from other countries every year to meet various needs. Though the country

Hard rock

Limestone

is not rich in mineral resources, several minerals can be found in this country. These minerals include limestone, silica sand, solid rock, gravel, porcelain etc.

Limestone: Limestone is primarily used as a raw material in the cement industry. In addition, it is also used in house building and glass industry; in producing steel, soap, bleaching powder, paper or paints. The country's first limestone mine was discovered in Takerghat of Sunamganj in the early 1960s. Apart from that, limestone is found in Lalghat and Bagli Bazar of Sunamganj; Jaflong, Jokiganj, Charga of Sylhet, Jahanpur and Paranagar of Naogaon district, Jaipurhat and Jamalganj of Joypurhat district.

Silica/ Glass Sand: It is the main raw material for glass production. It is also used in the manufacture of dyes and various chemicals. The deposits of glass sand in Bangladesh are notable. Glass sand is a quartz of fine to medium size with a colour ranging from yellow to grey. Glass sand deposits have been discovered on the surface of the earth or shallow depth of the earth at Balijuri, Shahjibazar and Chouddagram, and deep inside the earth's surface at Madhyapara and Barapukuria.

Hard Rock / Stone: Hard rock is widely used in the construction of infrastructure

such as houses, roads, railway lines, river embankments etc. In 1966, the first hard rock was discovered at a depth of approximately 182 metres from the surface at a place called Ranipukur under Badarganj Police Station of Rangpur district. Directorate of Geological Survey of Bangladesh discovered deposits of hard rock at a depth of 132 metres to 160 metres from the surface in Madhyapara, Dinajpur district. In addition, hard rock is found in Patnitala in Naogaon district, Bholaganj in Sylhet and Tentulia in Panchagarh.

Porcelain: Porcelain basically refers to high-quality clay made from clay minerals called kaolin. Porcelain is primarily used in ceramic industry in the production of various utensils, sanitary ware, dishware, electrical insulators, and so on. Porcelain deposits have been discovered at the surface or slightly below the surface in Vijaypur of Netrakona district, Vurunga of Sherpur district and Haitgaon, Kanchpur, Allahabad of Chittagong district; while within the surface in Madhyapara of Dinajpur district.

Gravel: Gravel is found in the northern border areas of the country, along the foothills of the Himalayas. They are carried by rivers from upstream areas during monsoons. Gravel is used in various developmental activities.

Sand used in construction: Numerous rivers flow through Bangladesh, which is one of the reasons why it is called a riverine country. This type of sand is found in the river beds of various rivers in the country. It is primarily composed of a combination of medium to coarse- grained quartz. However, it may also contain other minerals. This type of sand is widely used in the construction of various commercial and developmental infrastructures such as buildings, roads, dams or embankments, bridges.

Beach Sand Heavy Mineral: This type of mineral is found in the coastal areas of Bangladesh. Mainly Cox's Bazar, Badr Mokam, Maheshkhali, Kutubdia, and Matarbari have the deposits of beach sand heavy mineral. Due to the systematic and careful surveying operations, in 17 places along the coast of Bangladesh, there have been identified deposits of beach sand heavy mineral which are called placer deposits. Among them, 15 placer deposits are located near Cox's Bazar and Chittagong coastal areas and nearby islands. Among the heavy minerals are zircon, rutile, ilmenite, magnetite, monazite, leucoxene, kyanite, etc. These heavy minerals are used in welding, in the manufacture of refractory materials or heat-resistant products, and glass as well as in the extraction of zirconium metal.

16.3 Forest Resources

Forest resources play a significant role in the economy and environment of Bangladesh. The total land area of Bangladesh is 148,000 square kilometres, of which approximately 18% is covered by woodland/forest. These woodlands/forests consist of both natural and man-made forests and are habitat for a variety of flora and fauna.

The world's largest mangrove forest, Sundarbans, is located in Bangladesh and is a UNESCO World Heritage Site. A mangrove forest is a special type of forest of trees and shrubs that can survive in the intertidal zone of the sea. This forest covers an area of approximately 4,000 square kilometres and protects the coastal region, serving as a habitat for the Royal Bengal Tiger, spotted deer, saltwater crocodile, and various species of birds. Apart from Sundarbans, Bangladesh also has notable forest areas in Chittagong Hill Tracts, Srimangal and Madhavpur. Chittagong Hill Tracts are rich in biodiversity. Srimangal and Madhavpur lakes are famous for their tea gardens.

Forests make significant contributions to various environmental, social, and economic developments. The trees in the forest absorb carbon dioxide and release oxygen, and play an important role in climate regulation. Besides, forests help prevent soil erosion and maintain water cycles. Forests are home to numerous medicinal plants, which serve as an essential source for traditional and herbal medicines.

However, the forest resources of Bangladesh are facing several challenges, including deforestation, degradation, and fragmentation. The government of Bangladesh has been implementing various policies and programmes to protect forests and expand their coverage. It is essential to ensure sustainable management of forest resources for the benefit of future generations.

16.4 Water Resources

Water is an important natural resource of Bangladesh. The country has a dense network of rivers, canals, and wetlands. The country is situated in the delta of three major rivers, Ganga, Brahmaputra and Meghna, which is the largest river delta in the world. Besides these major rivers, there are more than 700 smaller rivers and tributaries that have crossed the country. In addition, the Haor regions of Bangladesh are significant sources of surface water resources. The Haor regions mainly consist of north-eastern districts of Bangladesh such as Sunamganj, Habiganj, Sylhet and a large part of Moulvibazar. Major Haors in Sylhet district include the Shanir Haor, Hakaluki Haor, Daker Haor, Makar Haor, Tanguar Haor etc. In winter, these areas experience water scarcity and are used for agricultural activities.

Newly found Bhola gas field

The Bay of Bengal in the southern part of the country is another vast water resource. The water resources of the country provide numerous benefits in different fields, including agriculture, transportation, irrigation, hydropower generation, and fishing. Additionally, it is assumed that there is a huge source of oil and gas deep in the Bay of Bengal. The water resources of Bangladesh are also vulnerable to natural disasters such as floods, cyclones and storms. Despite these challenges, the Bangladesh government has implemented various programmes and policies to improve water management, including flood control measures, river dredging, and promotion of sustainable water use practices.

16.5 Impact on the Environment due to Extraction of Natural Resources

Natural resources are essential for the existence and development of human civilization. However, their unplanned extraction can have significant adverse impacts on the environment. One of the most notable impacts on the environment due to the extraction of natural resources is destruction of ecosystems and wildlife habitats. This destruction is often irreversible and can lead to the extinction of various species, loss of biodiversity and disruption of food chains. For example, deforestation for timber harvesting and agricultural purposes has resulted in the destruction of large areas of forests. This results in soil erosion, loss of wildlife habitat and increased carbon emissions. When wildlife habitats are destroyed, they often migrate to human habitats in search of food and shelter. Then the germs of different diseases can be transmitted from these wildlife populations to humans. Such events are suspected to be the possible cause of the recent global outbreak of the coronavirus pandemic.

Burning fuels and natural gas as well as fossil fuels can also have a significant impact on environment. These extraction processes can result in greenhouse gas emissions as well as air and water pollution. Burning fossil fuels contributes to changes in the climate, which have extensive effects on the environment and human society. The process of extracting natural resources from mines can have adverse effects on the environment. For mining, it requires the removal of large amount of soil and rock which results in the loss of green grass cover, and causes soil erosion on the Earth's surface. Besides, mining can release toxic chemicals and heavy metals into the air and water, which can have long-term impacts on the environment and human health.

16.6 Caution in the Use of Natural Resources

We have observed that there is a close relationship between the types of natural resources and their availability. Most of the resources obtained from mining are non-renewable. For example, if coal, natural gas, mineral oil, limestone or porcelain, etc. are once extracted from mines, they cannot be replenished or recovered. In addition, if excessive extraction of mineral resources is done, future generations will face shortage of these resources. Excessive mining results in the destruction of fertile land on the Earth's surface. As a result, it leads to a loss of the land's utility not only in agriculture but also in other areas of use.

Renewable resources are safe to use. If we use them, there will be no shortage of resources in the near future. For example, solar energy, tidal energy, electricity, wind energy are renewable resources, and there is no possibility to run out in the near future. However, even though underground water, woodland, soil of agricultural land are renewable resources, excessive use can cause their scarcity in the near future. Therefore, where possible, it is necessary to utilize the water from rivers or canals, and stop using underground water. Cutting down trees from forests should be stopped, and new trees should be planted.

This country and this planet are our habitat. To keep it habitable, it is essential for us to preserve its natural environment and resources. As citizens of this country, we need to make everyone aware of the adverse effects of irresponsible use of natural resources, and support the sustainable practices that minimize environmental damage. Wherever possible, we must utilize renewable energy sources, reduce waste production, and minimize resource consumption. Thus, everyone must participate in efforts to protect natural resources and ecosystems for future generations.

ডিজিটাল তথ্য সেবা: টেলিমেডিসিন ও কৃষি কল সেন্টার

মাননীয় প্রধানমন্ত্রী শেখ হাসিনা ২০২১ সালের মধ্যে বাংলাদেশকে 'ডিজিটাল বাংলাদেশ' এ রূপান্তরিত করার ঘোষণা দিয়েছিলেন ২০০৮ সালে। ২০২১ সালের আগেই বাংলাদেশকে ডিজিটাল বাংলাদেশে রূপান্তর করা হয়েছে। বর্তমানে ডিজিটাল পদ্ধতিতে প্রায় সকল সেবাই জনগণের দোরগোড়ায় পৌঁছে দিচ্ছে সরকার।

ডিজিটাল স্বাস্থ্যসেবা- টেলিমেডিসিনের মাধ্যমে বিনামূল্যে ও সহজে স্বাস্থ্যবিষয়ক পরামর্শ প্রদান করা হচ্ছে। দেশের বিভিন্ন পর্যায়ের ১৮টি হাসপাতালে বর্তমানে উন্নতমানের টেলিমেডিসিন সেবা চালু আছে। টেলিমেডিসিন পদ্ধতিতে রোগীগণ বিশেষায়িত হাসপাতালের চিকিৎসকদের পরামর্শ নিতে পারছেন। মোবাইলের মাধ্যমেও রোগীগণ বিশেষায়িত চিকিৎসকের সেবা গ্রহণ করতে পারছেন। করোনা মহামারির সময়ে এই সেবা গুরুত্বপূর্ণ ভূমিকা রাখছে।

ডিজিটাল কৃষি সেবা- কৃষি সম্পর্কিত সর্বাধুনিক প্রযুক্তি, সেবা ও তথ্য সবার মাঝে ছড়িয়ে দেওয়ার লক্ষ্যে কৃষি কল সেন্টার চালু করা হয়েছে। কৃষি কল সেন্টারটি খামারবাড়ি, ঢাকাতে কৃষি তথ্য সার্ভিসের সদর দপ্তরে স্থাপিত। কৃষি কল সেন্টারের ১৬১২৩ নম্বরে ফোন করে কৃষি বিষয়ক যে কোনো সমস্যার তাৎক্ষণিক বিশেষজ্ঞ পরামর্শ নিতে পারেন দেশের জনগণ।

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সমৃদ্ধ বাংলাদেশ গড়ে তোলার জন্য যোগ্যতা অর্জন করো

– মাননীয় প্রধানমন্ত্রী শেখ হাসিনা

মিতব্যয়ী হওয়া ভালো

তথ্য, সেবা ও সামাজিক সমস্যা প্রতিকারের জন্য **'৩৩৩'** কলসেন্টারে ফোন করুন

নারী ও শিশু নির্যাতনের ঘটনা ঘটলে প্রতিকার ও প্রতিরোধের জন্য ন্যাশনাল হেল্পলাইন সেন্টার
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