DEPARTMENT OF EDUCATION

GRADE 9

SCIENCE

UNIT 6

EARTH AND ATMOSPHERE

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GRADE 9

SCIENCE

UNIT 6

EARTH AND ATMOSPHERE

IN THIS UNIT YOU WILL LEARN ABOUT:

TOPIC 1: THE STRUCTURE OF THE EARTH

TOPIC 2: ROCK CYCLE AND WEATHERING

TOPIC 3: STRUCTURE OF THE ATMOSPHERE

TOPIC 4: WEATHER

Acknowledgement

We acknowledge the contributions of all Secondary Teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

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PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 -2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD

Secretary for Education

UNIT INTRODUCTION

Dear Student,

Welcome to Unit 6 of your Grade 9 Science Course! I hope that you enjoyed studying the earlier Units. I also hope that this Unit, Earth and Atmosphere, will be an interesting and enjoyable subject to study too.

In this Unit, there are 19 Lessons on four Topics. The four topics are:

- **The Structure of the Earth**
- **Rock Cycle and Weathering**
- **Structure of the Atmosphere**
- **Weather**

There are four Lessons in the first Topic. The lessons will discuss about the planet Earth, its exterior and interior parts. You will also learn from this Topic about the volcanoes and different types of volcanoes.

The second Topic is composed of five Lessons and will discuss about the different types of rocks formed through the process of rock cycle which include processes of weathering and erosions.

In the third Topic, there are again four Lessons that will discuss about layers of atmosphere and properties of moving air.

The last Topic has five Lessons. It will talk about convection currents, precipitation and the cloud types. You will also learn from this Topic about climate, weather forecasting and reporting

Remember, you have to do all the activities and carry out the Practice Exercises after each lesson. Answers to Practice Exercises are at the end of each Topic.

If you have any problems in understanding any of the lessons in this Unit, please do not hesitate to inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this Unit now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below and work through the lessons.

Step 1 Start with Topic 1 and work through it in order. You may come across new terms in your lessons which are written in bold with an asterisk (*) For example in Lesson 1, you will come across **asteroids*.** Words like this will require you to look up their meaning in the glossary section at the end of this book.

Step 2 When you study Lesson 1, do the given Activities. When you complete the Activities, check your work. The answers are given at the end of the Lesson. (Note: Short lessons may not have an activity.)

Step 3 You will also do a Practice Exercise at the end of each Lesson. After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Topic.

Step 4 Then, revise and correct any mistake.

Step 5 When you have completed all of these steps, tick the check box for Lesson 1, on the Contents page, like this:

☑ Lesson 1: The Planet Earth

Then, go on to the next Lesson. Repeat this process until you complete all the Lessons on a Topic. When you have done this, revise using the Review Section.

Remember, as you complete each lesson; tick the box for that lesson on the Contents page. This will help you check your progress.

Assignment: Topic Tests and Unit Test

When you have completed all the lessons in a Topic, do the Topic Test for that Topic, in your Assignment Book. The Unit Book tells you when to do this. When you have completed all the Topic Tests for the Unit, revise well and do the Unit Test. The Assignment Book tells you when to do the Unit test.

When you have completed the entire Assignment Book, check and revise again before sending it to the Provincial Centre. If you have any questions, write them on the Student's page. Your teacher will advise you when he/she returns your marked Assignment.

The Topic Tests and the Unit Test in each Assignment will be marked by your Distance Teacher. The marks you score in each Assignment will count towards the final result. If you score less than 50%, you will repeat that Assignment.

Remember, if you score less than 50% in three consecutive Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all Assignments.

TOPIC 1

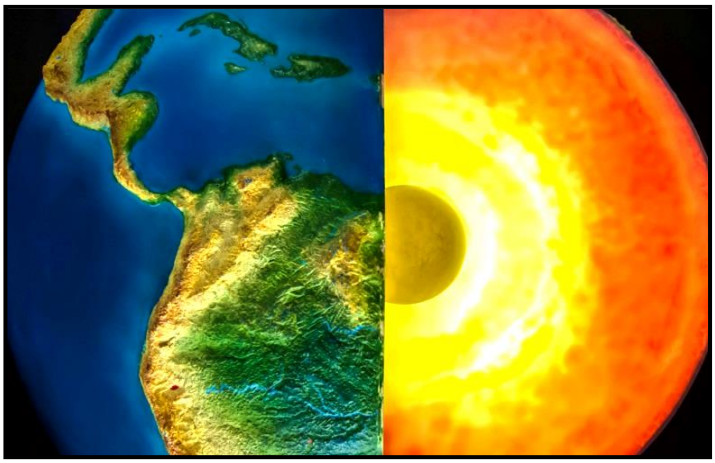
THE STRUCTURE OF THE EARTH

In this topic you will learn about:

- **the planet Earth**
- **the exterior and the interior part of the Earth**
- **volcanoes**
- **types of volcanoes**

INTRODUCTION TO TOPIC 1: THE STRUCTURE OF THE EARTH

Many children (and adults) do not have a formal understanding of the structure of the earth or earth processes, because in many developed and developing countries around the world, earth science education is lacking. This is unfortunate, as a large number of people all over the world live at or near areas where earth processes can and create large amounts of damage and living in these areas increases people's vulnerability to hazards.



The Earth

Volcanic eruptions, earthquakes, landslides, floods, and tsunamis are all examples of earth processes that affect many people every year

For these reasons, basic lessons on earth sciences will be discussed on this topic. A basic knowledge of the earth is important. The purpose of this topic is to provide examples of lessons and activities that can be used in developing countries like Papua New Guinea, to help teach children about basic earth science principles and in particular, teach children about volcanoes and volcano safety tips.

Topic 1 will include lessons on the interior and exterior parts of the earth and the different types of volcanoes. Following are some questions you may be asking yourself right now.

Volcano

- What are the different planets in the solar system?
- What are the different layers of the earth?
- What are volcanoes and different stages of volcanoes?
- How are volcanoes formed?
- What is the Ring of Fire and a Tsunami?

In this Topic, you will find the answers to these questions and all other questions relating to the structure of the earth.

Lesson 1: The Planet Earth

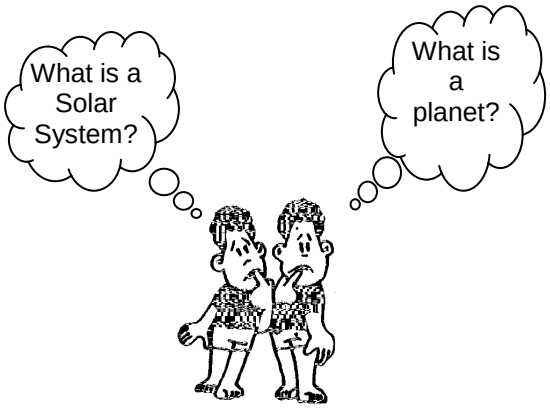
Welcome to Lesson 1. In this lesson we will look closely on our planet earth and where it is located in the solar system, the galaxy and the universe. We will also look at the other planets in the solar system as well.

Your Aims:

- identify the position of earth in the solar system of the universe
- revise solar system, universe, Milky Way, the eight planets and their position in the solar system

The Solar System

The term "solar" is simply a word that means "of the Sun" and system is just a collection of objects that interact to form a whole. To put the two words together, solar system is a group of objects that interact with one another. The important interaction for each object being connected or part of the Sun.



What are the Objects in the Solar System?
There are many different types of objects found in the solar system. The solar system includes everything that travels around the Sun.

It includes planets, moons, **asteroids***, **comets***, gases and dust because they orbit or travel around the sun.

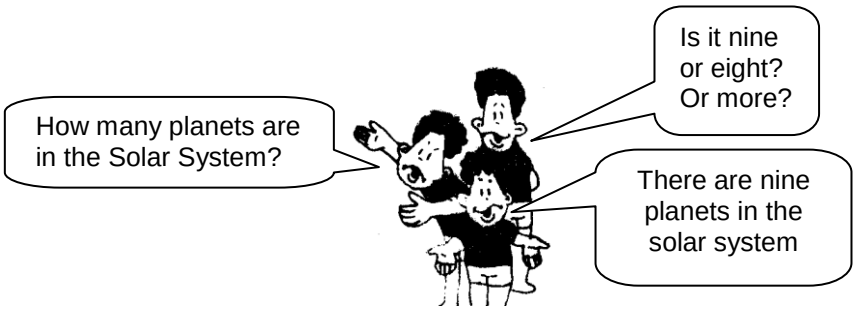
The Planet Earth

As you may have known already, a **planet** is basically, a large heavenly body which revolves or moves around the sun, rotates on its axis and shines by reflecting light from the sun. You and I live on the planet called Earth which is the only planet in our solar system that has life.

Long ago people thought that the earth was flat, it was believed that the sun travelled around the earth, but this was not so. The earth is round and it travels around the sun and rotates on its axis.

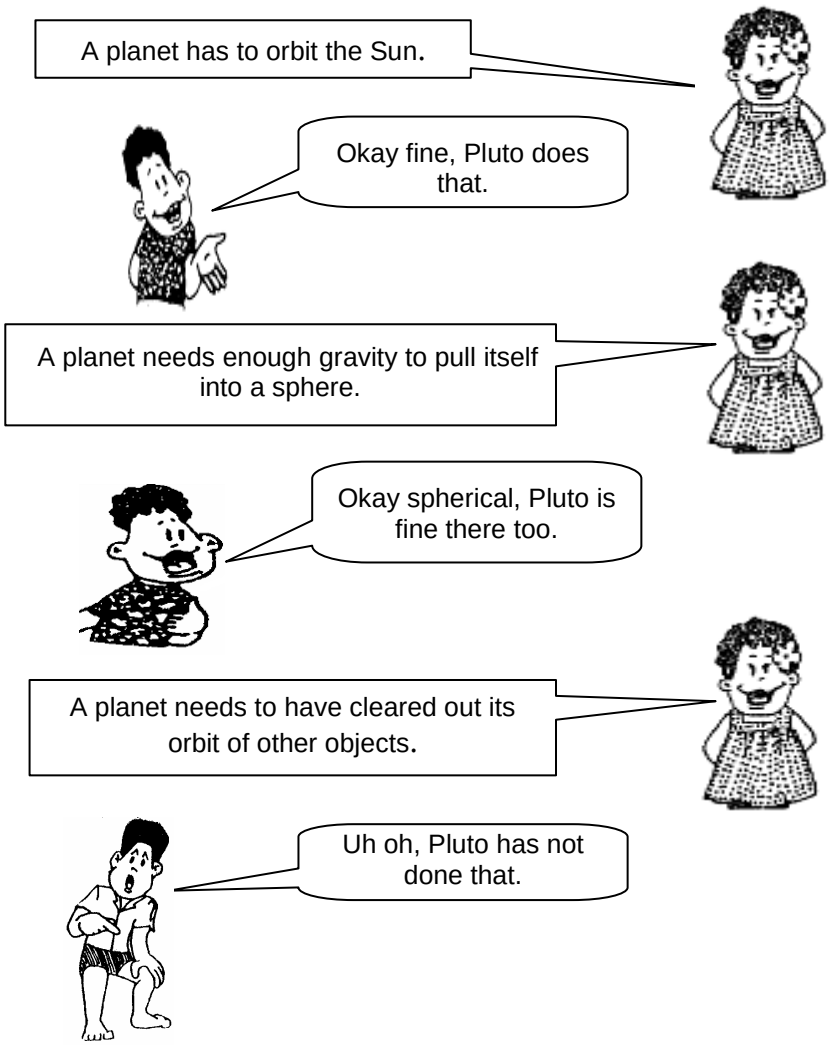
How many Planets are there in the Solar System?

Some people start grumbling when you ask, how many planets are there in the solar system?



In response to this uncertainty, the International Astronomical Union (IAU) met in 2006, and argued for, and against Pluto's planet hood. Some astronomers advocated widening the number of planets to twelve, including Pluto, its moon Charon, the Asteroid Ceres, and the newly discovered Eris. In the end, they changed the definition of what makes a planet, and sadly, Pluto does not make the cut:

Here are the new requirements of planet hood status:

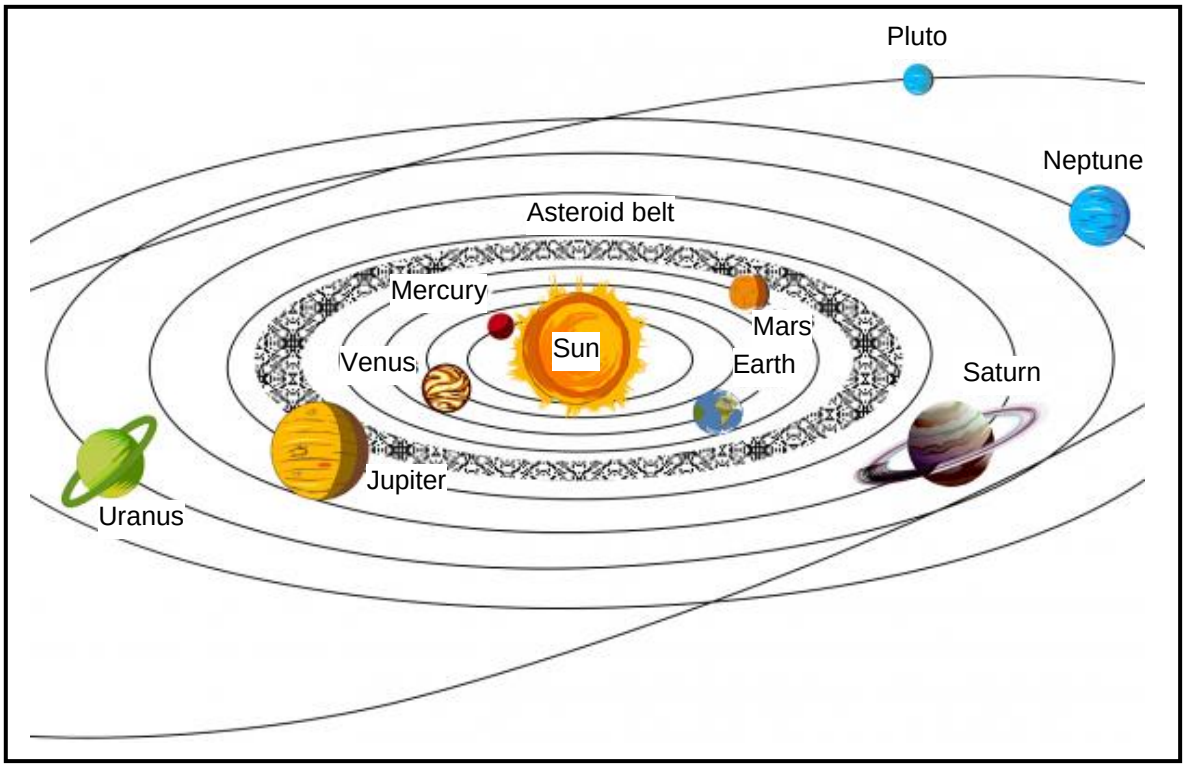


For example, planet Earth accounts for a million times the rest of the material in its orbit, while Pluto is just a fraction of the icy objects in its realm. According to the IAU's definition for planet above, there are 8 known planets in the Solar System: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune**.** Pluto is no longer considered a planet under the IAU definition. The final decision was to demote **Pluto** from planet to **dwarf planet**.

There are **nine planets**. The nine planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and dwarf planet Pluto. Now, let us look at the diagram below. The closest planet to the sun is Mercury followed by Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune being the farthest from the sun.

These planets all orbit or travel around the sun. The gravity of the Sun keeps them in orbit. Just as the moon orbits the Earth because of the pull of Earth's gravity, the Earth orbits the Sun because of the pull of the Sun's gravity. The Earth travels in an **elliptical orbit*** around the Sun rather than just pulled in all the way. This happens because the Earth has a **velocity*** in the direction **perpendicular*** to the force of the Sun's pull of gravity. If the Sun was not there, the Earth would travel in a straight line. But the gravity of the Sun alters its course causing it to travel around the Sun, in a shape very near to a circle.

If the Earth was to orbit the Sun in a circle, the Earth's speed around the Sun would be constant. We can think of this as the Earth's average speed. However, because the Earth's orbit is elliptical, the speed of the Earth varies throughout the year. The speed of the Earth is fastest when it is closest to the sun, in, and slowest when it is farthest away from the sun.



The solar system is made up of everything that orbits the sun

In the diagram above, you will notice that, Mercury, Venus, Mars, and Earth are **small planets**. Jupiter and Saturn are **huge planets** with Jupiter being the largest of all the planets and Mercury the smallest.

The four smaller planets, Mercury, Venus. Mars and Earth close to the sun are called **inner planets**. The other four bigger, Jupiter, Saturn, Uranus and Neptune, with dwarf planet Pluto are known as the **outer planets** because they are far away from the sun.

Activity 1.1: **Now you test yourself by doing this activity.**

Complete the table below by putting all the nine planets into their correct group.

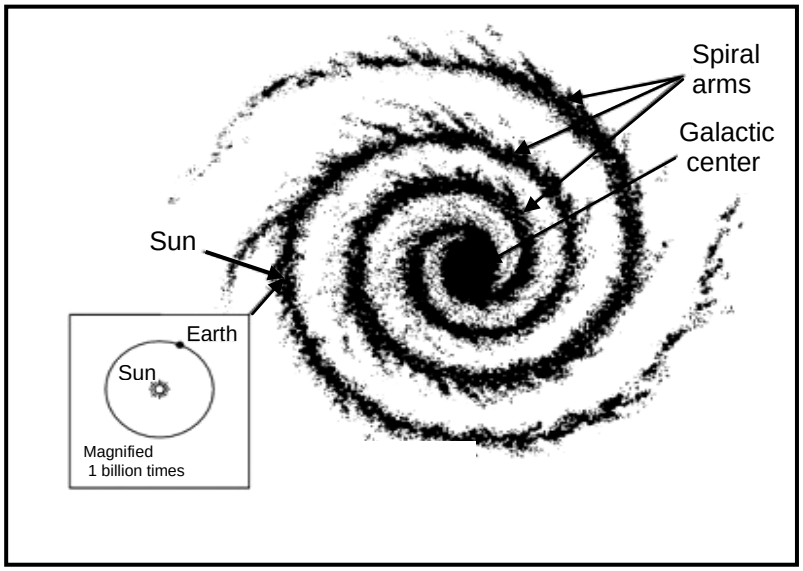
Inner Planets	Outer Planets

Milky Way Galaxy

Most nights when you look up into the sky you see thousands of stars shining. All this stars including our solar system make up what is called a **galaxy**. A **galaxy** is a collection of millions of stars, planets, moons, asteroids or rocks, dust and gases all gathered together as a group by **gravity**. You may have learnt that gravity is what keeps objects on the Earth. But you may have not learnt that any object with mass has gravity; the more mass something has the more gravitational pull it creates. Therefore, very massive objects like the Sun and Jupiter have significantly more gravity than Earth. Gravity keeps the Moon going around the Earth, the Earth going around the Sun, and the Sun going around the centre of the Milky Way. It is the force that governs motion in the universe.

There are many other galaxies in the universe. Our solar system belongs to the galaxy called, the **Milky Way**. The stars we see at night belong to our galaxy.

The picture on the right shows our galaxy, the "Milky Way". It is a large spiral shaped galaxy containing around 100 billion stars. The sun is one of the millions of stars in our galaxy.



This is the Milky Way galaxy. Can you see the sun? That is where our solar system with the planets is located

The Universe

Now, have you heard about the word called **Universe**? I believe you have. The Universe is all of the billions of galaxies, each containing millions or billions of stars.

The Earth is just a very small part of the universe. Our planet Earth and all the other planets in our solar system make up the **universe**. The universe is very, very big. Try looking up at the sky on a clear, starry night. What you see is just a part of the universe. You can never see the entire universe. No one even knows where the universe ends or if it goes on forever.

Recalling what we have learnt so far:
The **solar system** is made up of the sun and the nine planets and other heavenly bodies that orbit around the sun. The solar system is part of a group of millions of stars called the **galaxy**. All the billions of galaxies together make up the whole **universe**, which is so great, that scientists still do not understand.

Activity 1.2: **Now test yourself by doing this activity.**

State whether each of these statements are true or false by writing T if the statement is true and F if the statement is false on the space provided below.

1. _____The solar system is a group of stars that orbit the sun.
2. _____The sun is not a star.
3. _____Mercury is the closest planet to the sun.
4. _____Human beings live on planet Jupiter.
5. _____Milky Way is a galaxy.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 1.

Summary

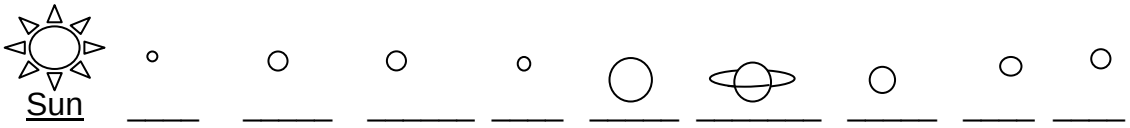
You have come to the end of Lesson 1. In this lesson you have learnt that:

- there are nine planets; Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and dwarf planet Pluto.
- earth is the third planet from the sun.
- this group of planets and their rotation or orbit around the sun is known as the Solar system.
- a galaxy is a collection of stars, planets, moons, asteroids, dust and gases gathered together by a force.
- our solar system belongs to the galaxy called the, Milky Way
- there are billions of other galaxies, that make up the universe.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

A. Fill in the blanks, by identifying the planets below, from the closest to the sun to the farthest.



___ ____ _____ ___ ____ _____ ____ ___ ___

B. Explain each of these items.

1. Solar System

_____
_____

2. Galaxy

_____
_____

3. Universe

_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activities

Activity 1.1

Inner Planets	Outer Planets
Mercury	Jupiter
Venus	Saturn
Earth	Uranus
Mars	Neptune
	Pluto

Activity 1.2

1. False
2. False
3. True
4. False
5. True

Lesson 2: The Interior and Exterior of the Earth

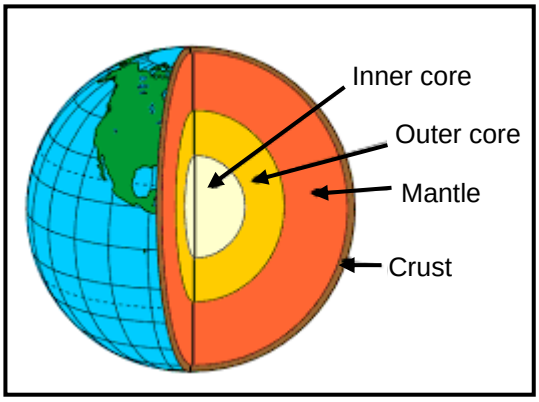
Welcome to Lesson 2. Our home the planet Earth, is the only planet in our solar system known to have life. All of the things we need to survive are provided under a thin layer of atmosphere that separates us from the uninhabitable void of space. Earth is made up of complex, interactive systems that are often unpredictable. Air, water, land, and life including humans combine forces to create a constantly changing environment that we are striving to understand. As we go on with the lesson you will study more about the Earth, the solar system and the eight planets.

Your Aims:

- describe the layers of the Earth's interior (inner part)
- describe the characteristics of the Earth's interior

The Structure of the Earth

The Earth is sphere with a diameter of about 12,700 kilometres. The Earth consists of four concentric layers: **crust**, **mantle**, **outer core, inner core**.



Layers of the earth

Layers of the earth

1. The outer shell of the Earth is called the **CRUST.**
2. The next layer is called the **MANTLE.**
3. The next layer is the liquid **OUTER CORE**
4. The middle bit is called the solid **INNER CORE**

Inside the Earth

The earth's interior is composed of four layers, **three solid** and **one liquid**. The liquid is not magma but **molten***metal, nearly as hot as the surface of the sun .As we go deeper and deeper into the earth the temperature and pressure rises.

1. The Core

The inner part of the earth is the **core**. The core is a dense ball of the elements iron and nickel. It is divided into two layers, the **inner core** and the **outer core**. The core temperature is believed to be 5000-6000°C.

What does the core consist of?

A. **Inner Core**

The inner core is a bit in the middle, the centre of the earth. It is solid and made up of iron and nickel with temperatures of up to 5,500degrees centigrade. Although this inner core is extremely hot, the pressure is so high the iron cannot melt. It is like the engine room of the Earth with its immense heat energy.

B. **Outer Core**

The outer core is the layer surrounding the inner core. It is a liquid layer, also made up of iron and nickel. and about 10% sulphur and oxygen. It is still extremely hot, with temperatures similar to the inner core.

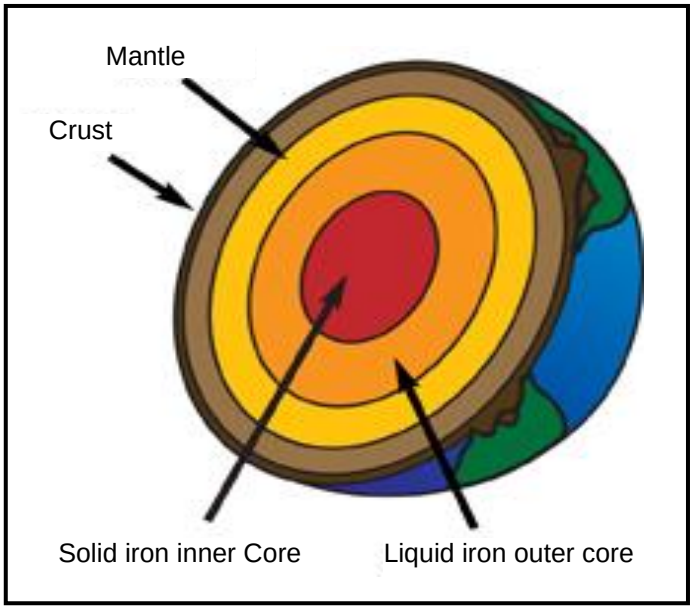


Diagram showing the inner and outer core of the earth

What influence does the core have?

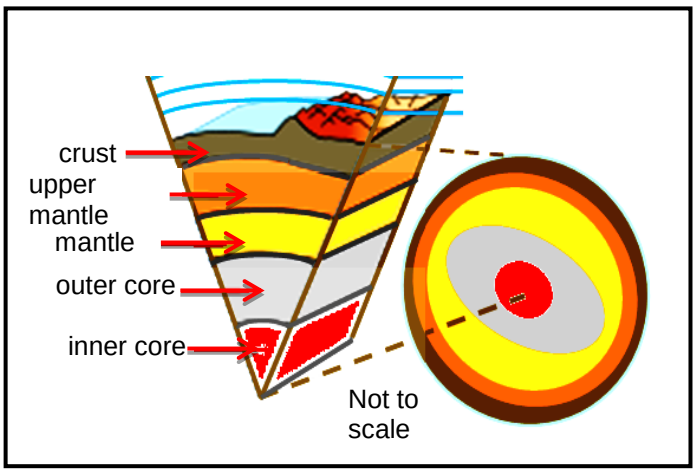
Because the earth rotates, the outer core spins, the inner core does not spin because it is solid. This gives a kind of **dynamo*** effect and causes the **earth's magnetism*.**

2. Mantle (River of Rock)

The layer above the outer core is the **mantle**. It is the widest section of the Earth. It has a thickness of approximately 2,900km. It is made up of semi-molten rock called **magma**.

In the upper parts of the mantle the rock is hard, but lower down the rock it is soft and beginning to melt that it flows under pressure like road tar. This creates very slow-moving currents as hot rock rises from the depths and cooler rock descends.

The mantle appears to be divided into two layers: the **upper mantle** and the **lower mantle.** Science deals with the structure of the mantle in two different ways. One way is based on its chemical construction (the material), the other is on the way layers stream or move.



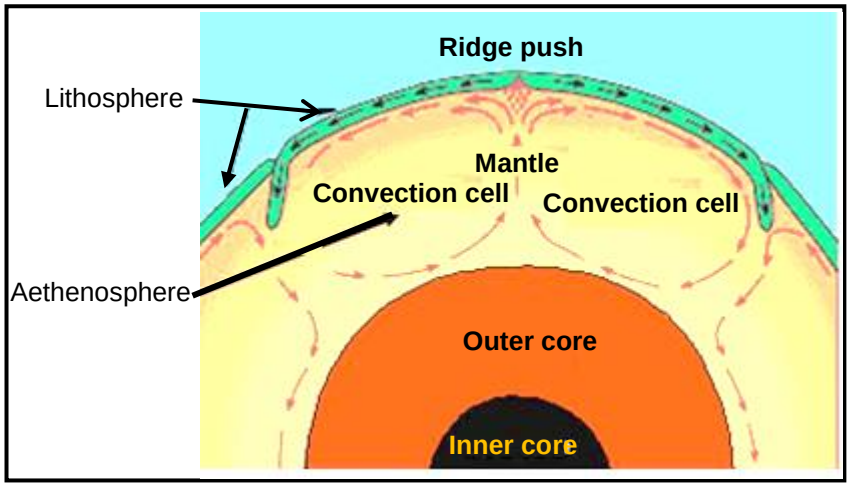
Earth's Cross Section

'

The Way Layers Stream or Move
From this perspective, you look at the outer mantle and the crust together.

Here we make a difference in asthenosphere and lithosphere.

1. **Asthenosphere** -the tough liquid part of the outer mantle where convection occurs.
2. **Lithosphere** –the solid and stiffer part of the outer mantle and the crust where the plates are. The lithosphere 'floats' on the asthenosphere, like ice on water.



The way layers stream or move

What influence does the mantle have?
Convection currents
Because the core is so hot, it **radiates*** natural heat to the upper layers. Because of this a current of heat comes into being. A current of heat flows from the core to the crust. This is also known as the **convection current.** Convection current also takes place in the mantle. This current cools down as it comes closer to the surface of the earth. As a result, the rising of the current decreases and goes into horizontal direction along the bottom of the crust. When the current cools down more, the convection current descends again and goes to the inner earth. There the temperature increases and the current rises again. This goes on and on.

3. The Crust

It is the outer layer of the earth. The crust covers the mantle and is the earth's hard outer shell and the solid rock surface on which we are living. Compared to the other layers the crust is much thinner.

The crust is very thin (average 20 km). This does not sound very thin but if you were to imagine the Earth as a football, the crust would be about ½millimetre thick. It floats upon the softer, denser mantle**.** The crust is made up of solid material which is not the same everywhere.

What does the crust consist of?
The crust consists of two parts: the **oceanic** and the **continental crust**.
These two parts are made up of different types of rock, composed mainly of sedimentary, metamorphic and igneous rock which will be described in the next lessons.

1. **Oceanic Crust**

As the name already suggests, this crust is below the oceans which carries water and goes to a depth of roughly10 kilometres. The rocks of the oceanic

crust are very young compared with the rocks of the continental crust. The rocks of the oceanic crust are not older than 200 million years.

The material of which the oceanic crust consists of the greater part is **tholeitic basalt** (this is basalt without olivine). **Basalt** has a dark, fine and gritty volcanic structure. It is formed out of very liquid lava, which cools off quickly. The grains are so small that they are only visible under a microscope.

2. Continental Crust

When you look at the globe, you see that the surface of the earth consists of a lot of water (71%). The other 29% consists of land. Continental crust carries land which is divided into **continents***. The different continents arranged in decreasing order of size are: Eurasia (Europe and Asia together), Africa, North-America, South-America, Antarctica and Australia.

The Continental crust underlies the continents which extend down to 35 kilometres on average. The continental crust is older than the oceanic crust; some rocks are 3.8 billion years old. The continental crust mainly consists of igneous rocks and is divided into two layers. The upper part mainly consists of granite rocks, while the lower part consists of basalt and diorite. **Granite** is lightly-coloured, coarse-grain, magma. **Diorite** has the same composition, but it is scarcer than granite and is probably formed by impurities in the granite-magma.

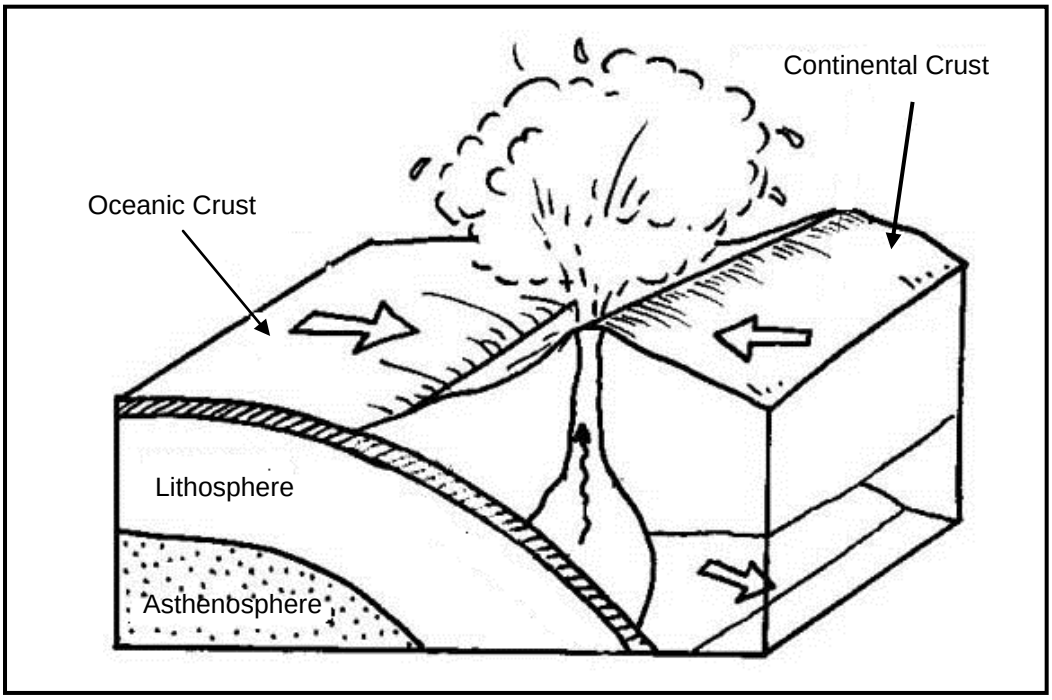
Which influence does the crust have?

The crust itself has no influence on the earth, but the constant moving of the crust does, caused by the influence of the convection current. To be more precise, this convection current actually causes the earth plates to move and sometimes touch each other. The convection current along the bottom of the crust causes the movement of the tectonic plates*. The movement of these plates goes very slowly. The bumping of two tectonic plates causes an earthquake.

When the current comes at a weaker part of the crust, for example at a volcano, magma* comes above the earth's surface, volcanoes can erupt. Because of all these on-going movements in the last millions of years, mountains and valleys have been formed, and that is why the surface of the earth looks as it is now.

The form of the surface of the earth has its daily influence on the way people live and work. An example: the building of houses. When you build a house in the mountains, you build it in another way than on flat land.

In the mountains, the bottom is more solid than on flat land. Volcanoes and earthquakes also have their direct influence on the people who live near places where they occur. It destroys their houses and many times people are killed or wounded.



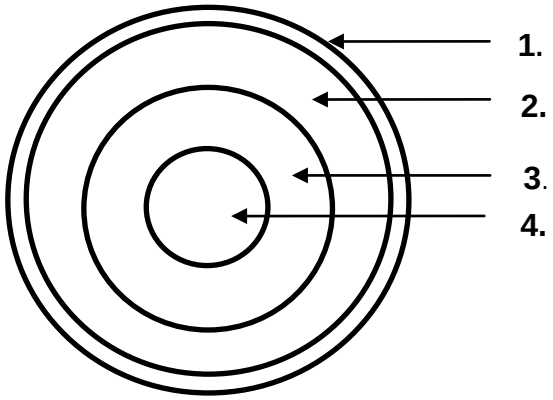
Oceanic and continental crust movement
caused by convection current

Activity: **Now test yourself by doing this activity.**

A. Can you work out which layer of the earth each of these statements refers to? Write your answer on the space provided for.

_____1. I am dense, very hot, made mostly of solid iron and nickel.
_____2. I am iron and nickel too, but I'm liquid.
_____3. I am a semi-solid with convection currents circulating in me.
_____4. I just hang around on the outside.

B. Label the diagram below as indicated.



C. Read the definitions and fill in the blanks using the given words in the box.

outer	layer	oceans	centre	crust
hot	skin	magnetic	liquid	5000

1. Crust – the _____surface of the Earth. The crust is quite thin like the _____of an orange and is thinner under the _____.

2. Inner Core - the solid iron-nickel _____ of the Earth that is very _____and under great pressure.

3. Mantle – a rocky_____ located under the _____. It is extremely hot¬, about _____degrees Celsius.

4. Outer core - made of metal so hot that is_____. This layer moves slowly and produces a _____field.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 1.

Summary

You have come to the end of Lesson 2. In this lesson you have learnt that:

- the earth consists of the four concentric layers which are the outer and inner core, the mantle and the crust.
- the inner part of the earth is the core. The core is a dense ball of the elements iron and nickel. It is divided into two layers, the inner core and the outer core.
- the layer above the core is the mantle. It is the widest section of the Earth. It has a thickness of approximately 2,900 km
- asthenosphere is the tough liquid part of the outer mantle.
- lithosphere is the stiffer part of the outer mantle and the crust. The lithosphere 'floats' on the asthenosphere, like ice on water.
- the crust covers the mantle and is the earth's hard outer shell, the surface on which we are living.
- the crust consists of two parts: the oceanic and the continental crust.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

Practice Exercise 2

Encircle the letter of the best answer.

1. Which of the following best describes the material that makes up the earth's asthenosphere? A

   A. rigid solid.
   B. solid that is able to flow.
   C. gas under great pressure
   D. liquid at high temperature.

---

2. The lithosphere is made up of the upper mantle and the_____.

   A. core B. crust
   C. hydrosphere D. asthenosphere

---

3. The part of the earth that is solid but has the ability to flow is the

   A. inner core.
   B. lithosphere.
   C. oceanic crust.
   D. asthenosphere.

---

4. Which zone of the earth is made up of liquid iron?

   A. Outer core
   B. Inner core
   C. Upper mantle
   D. Asthenosphere

---

5. The core of the earth is made mostly of

   A. iron and nickel.
   B. iron and silicon.
   C. copper and nickel .
   D. oxygen and silicon.

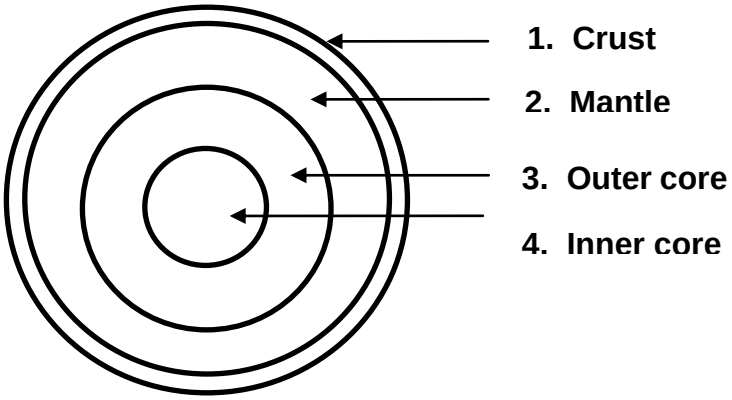
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

A**.**

1**.** Inner core
2. Outer core
3. Mantle
4. Crust

B.



C.

1. Crust – the outer surface of the Earth. The crust is quite thin like the skin of an orange and is thinner under the oceans.

2. Inner Core- the solid iron-nickel centre of the Earth that is very hot and under great pressure.

3. Mantle – a rocky layer located under the crust. It is extremely hot about 500 degrees Celsius.

4. Outer core- made of metal so hot that is liquid. This layer moves slowly and produces a magnetic field.

Lesson 3: Volcanoes

Welcome to Lesson 3. From the previous lessons, you learned about the exterior and interior parts of the earth. The surface (exterior) of the earth is divided into active and stable areas. Active areas refer to areas where the land is changing as a result of volcanoes, earthquakes and uplift. Papua New Guinea is a very active area of the earth's crust (surface) and this is shown by a number of volcanoes which smoke, steam and sometimes pouring out lava, and causing earthquakes. In this lesson, you will learn more about these volcanoes. Stable areas refer to areas where very little geological activity has taken place over a very long period of time.

Your Aims:

- define volcano
- explain the formation of volcanoes
- explain the activities of magma and its effects

Defining Volcano

A **volcano** is a conical hill or mountain formed by material from the mantle being forced through an opening or vent in the Earth's crust. Volcanoes are often called windows to the interior of the earth.

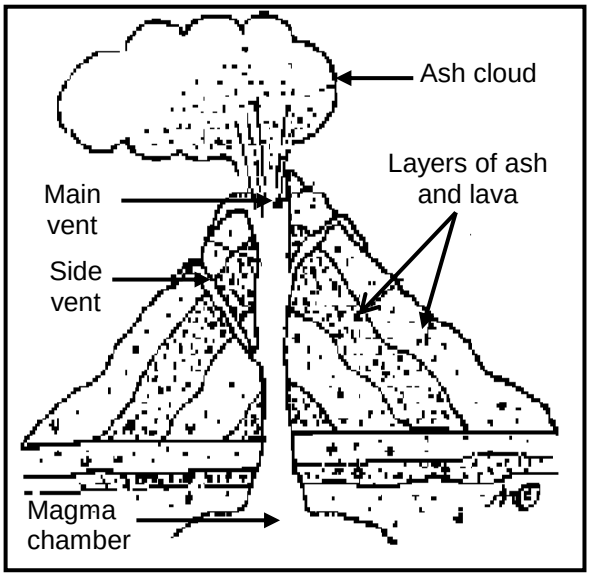
The word **volcanism** or *vulcanism* comes from the word, **Vulcan**. The name ancient Romans gave to their god of fire, and describe all types of heating in the earth's crust (surface). There are many different effects of heating, but volcanoes are the most well-known. The Romans believed that the god lived beneath a volcanic island off the Italian coast. They called the island **Vulcano**. Therefore, a volcano is a hole or crack in the Earth from which molten rock called magma and gas are produced.

How many volcanoes are there?

There are more than 1500 active volcanoes on the Earth. Eighty (80) are currently known where many are under the oceans. Active volcanoes in Papua New Guinea are found mainly in Madang and Rabaul.

The Formation of Volcanoes

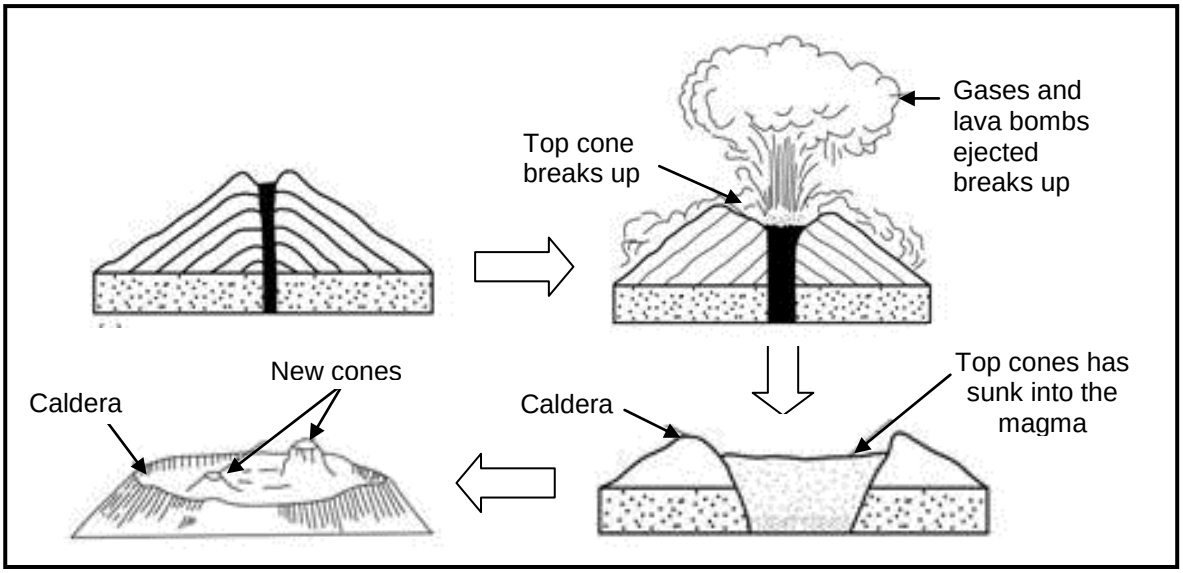
Volcanoes are formed by powerful forces inside the earth pushing up magma (molten rock material) through the cracks in the crust. Magma is formed from the extreme heat in the earth's interior which is 160 km below the surface.



Parts of Volcano

The gas filled magma gradually rises because of pressure and the fact that it is lighter than the surrounding solid rock. The magma forms a large chamber of a few kilometres below the surface. This magma chamber is the source of the molten material for volcano. Gas and magma burst through the surface in an opening called the **central vent**.

Materials thrown out of a volcano include steam, gas-filled magma, rock fragments, ash, froth, dust and smoke .Magma flowing over the surface of the land is called **lava**. When the lava cools a type of rock called igneous rock is formed. (You will learn more about rocks in the next topic).



Formation of Volcano- Caldera

The Activities of Magma and Its effect on the Crust

A volcano produces steam, gases-filled magma, rock fragments, ash, froth, dust and smoke. **Magma i**s a mixture of molten rock and gases. Holes in the Earth's crust which allow magma to come to the surface are called **vents**. When magma comes out of the vent, the volcano is erupting. When magma flows out of the vent smoothly in all directions it is called **lava**. Because the earth's surface and the air above it are much cooler than molten rock, lava flows quickly and usually flows for only a short distance before becoming solid. In this way the lava piles up to form a regular cone shape. Some volcanic cones become very large.

When the magma has a lot of gas in it, the volcano will spit out ash, which is a mixture of dust and gas. Most of the dust will fall down close to the vent and less will fall further away. However, when the hot clouds of ash are sent high up into the sky and there is a strong wind blowing at the time, volcanic ash can be carried a very long way and deposited over a very large area. For example, ash from the eruption of Lamington in Oro Province in 1951 fell in Port Moresby, a distance of 130 kilometres away. The rich soils in many parts of the world have been built up by deposits of volcanic ash. The soils of the gazelle Peninsula of East New Britain are good example of this.

Why do volcanoes erupt?
The Earth's crust is made up of huge **slabs*** called **plates**, which fit together like a jigsaw puzzle. These plates sometimes move. The friction causes earthquakes and volcanic eruptions near the edges of the plates. The theory that explains this process is called **plate tectonics**.

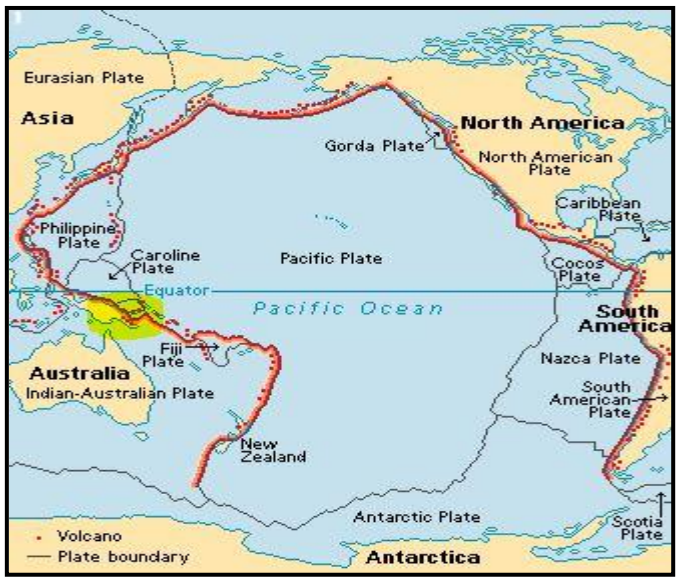
What are plate tectonics?
The theory of plate tectonics is an interesting story of continents drifting from place to place and breaking apart, colliding, and grinding against each other. The plate tectonic theory is supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates that move relative to one another. The plates are all moving in different directions and at different speeds. Sometimes the plates crash together, pull apart, or side swipe each other. When this happens, it commonly results in earthquakes.

What is a Tsunami?
A **tsunami** is a large ocean wave usually caused by an underwater earthquake or a volcanic explosion. Tsunamis are NOT tidal waves. Tidal waves are caused by the forces of the moon, sun, and planets upon the tides, as well as the wind as it moves over the water. With typical waves, water flows in circles, but with a tsunami, water flows straight. This is why tsunamis cause so much damage.

What is the Ring of Fire?

The Pacific Ring of Fire is an area of frequent earthquakes and volcanic eruptions encircling the **basin*** of the Pacific Ocean.

The Ring of Fire has 452 volcanoes and is home to over 50% of the world's active and dormant volcanoes. 90% of the world's earthquakes and 81% of the world's largest earthquakes occur along the Ring of Fire.



The Pacific tectonic feature known as the "Ring of Fire" passes through Indonesia and Papua New Guinea (shaded in yellow) and passes near Australia.

What are the different stages of volcanoes?
Scientists have categorized volcanoes into three main categories: **active**, **dormant**, and **extinct**.

1. An **active volcano** is one which has recently erupted and there is a possibility that it may erupt soon.

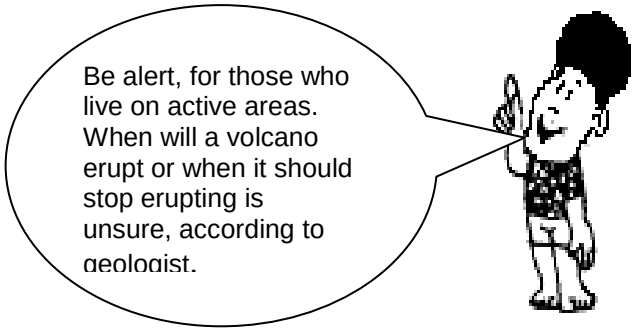
In Madang Province, Karkar and Manam are both active as are Mt Tavurvur in Rabaul, East New Britain, Mount Ulawun in West New Britain, and Bagana in the North Solomons.

Mount Tavurvur is considered one of the most active volcanoes in the region, most recently erupted in August 2014, early 2013 and recording other eruptions in 2011, 2010, 2006, 2005 and 2002, since the major 1994 explosion.

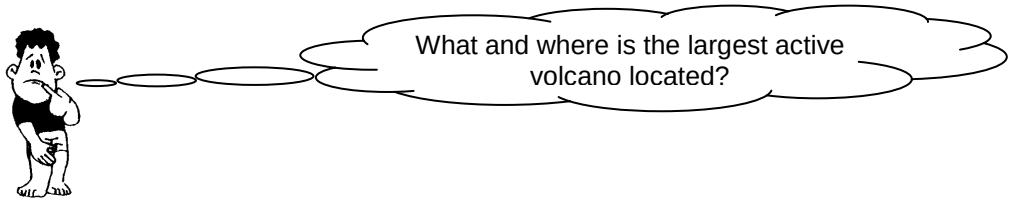
This active Volcano is Mt. Tavurvur in Rabaul

Mount Fujiyama, also popularly known as Mount Fuji, is an active volcano which last erupted in 1708. It is incidentally the tallest mountain in Japan. If you are visiting Tokyo, the capital of Japan, look in the west on a clear day and you will be able to see Mount Fuji. It is an iconic volcano. Mount Fuji is 3,776 meters high and it is snow clad throughout the year, with five lakes surrounding it.

Currently in a state of dormancy, there has not been any eruption reported for more than 300 years. The last known eruption lasted for about 3 weeks during which it covered the surrounding villages with ash and cinders.



Mount Fuji is now a popular tourist location with a large number of climbers actively scaling the mountain top.



The world's largest, active volcano is Mauna Loa in Hawaii, where famous coffee is grown in the rich volcanic soils. Mauna Loa is 13,677 feet above sea level. From its base below sea level to its summit, Mauna Loa is taller than Mount Everest

2. A **dormant volcano** is one which has not erupted in a long time but there is a possibility it can erupt in the future.

People in Oro Province did not know that Mt. Lamington was a dormant volcano but it erupted in 1951 killing between 3000 and 4000 people. Krakatoa was a dormant volcano in Indonesia, which awakened and produced one of the biggest volcanic eruptions in 1883. So massive was the eruption that its sound was heard as far away as Australia. It is widely reported as the loudest sound heard in recorded history.

The Krakatoa eruption created a huge amount of ash cloud which covered the Earth and reduced global temperatures for 5 years! A total of 40,000 people died in that explosion and an entire chain of the volcanic island was destroyed.

Mount Pelee was a dormant volcano situated in the Caribbean island of Martinique. In 1902, it erupted in a massive horizontal explosion sending huge clouds of ash released towards the nearby town of Saint-Pierre. The side of the volcano exploded and lava flowed straight into the town, killing 30,000 people in a matter of minutes. It is regarded as one of the biggest and most devastating volcanic eruptions of the 20th century, a benchmark for future eruptions.

3. An **extinct volcano** is one which has erupted thousands of years ago and there's no possibility of eruption. There is a line of extinct volcanoes running right through the highlands. Mt.Giluwe and Mount Hagen are the remains of extinct volcanoes.

Notable Volcano Eruptions in Papua New Guinea

The Rabaul Volcano Observatory (RVO) was established after the 1937 eruption and is responsible for monitoring the activity of the 14 active and 23 dormant volcanoes spread along three volcanic arc throughout Papua New Guinea. More than 150 eruptions have been recorded in the last 200 years.

On the morning of 19 September 1994, both Vulcan and Tavurvur erupted, which are two of the volcanoes in the Rabaul caldera. The ash from the eruption destroyed many buildings in Rabaul and the airport which was close to Tavurvur could no longer be used. The airport at Tokua, near Kokopo was quickly brought into use. Many people and businesses had to be evacuated from Rabaul and moved to Kokopo.

The most recent eruption of Mt Tavurvur in Rabaul, East New Britain began in the early hours of Friday morning, 29th of August 2014. "An eruption commenced from Tavurvur from between 3:30am and 4:00am," a bulletin from the Rabaul Volcanological Observatory said. Local resident described the eruption of lava and rocks as savage and said lightning strikes could be seen amongst the ash cloud. Schools and some shops have been closed, but authorities had not issued an evacuation order for Rabaul residents. By comparison this eruption is a relatively small event.

Volcano Safety Tips

1. First of all, **have a disaster plan** and know whether or not you are at risk for danger. Be prepared for mudslides, flash floods, earthquakes, ash falling, acid rain and tsunamis.

   Prepare a disaster supplies kit for your home and car.
   Include a first aid kit, canned food and a can opener, bottled water, battery-operated radio, flashlight, protective clothing, dust mask, goggles and sturdy shoes. Don't forget; **know all of your evacuation routes**.

2. **Follow the evacuation order** issued by authorities. Avoid areas downwind and river valleys downstream of the volcano. If you are caught indoors, close all windows and doors, put machinery inside a barn, and bring animals inside.

If you are trapped outdoors, seek shelter indoors. If you are caught in falling rocks, roll into a ball and protect your head. If you are caught near a stream, be aware of mudflows and move to higher ground. Protect yourself when ash falls by wearing long-sleeved shirts and long pants. Use goggles to protect your eyes. Wear a dust mask and keep car engines off.

3. **Follow safety rules.** Cover your mouth and nose. Volcanic ash can irritate your respiratory system. Wear goggles and protect your eyes. Keep your skin covered. Clear roofs of ash, because the ash is very heavy and can cause the building to collapse.

Activity: **Now test yourself by doing this activity.**

Answer the following questions below.

1. What evidence indicates that an area of the crust is unstable?

_____
_____
_____

---

2. What is a volcano?

_____
_____

---

3. What materials are released by volcanic action?

_____
_____

---

4. What is the difference between magma and lava?

_____
_____

---

5. Where are magma and lava likely to be found?

_____
_____

---

6. How does a dormant volcano differ from an extinct one?

_____
_____

7. If you live near a volcano would you prefer it to be an ash or a lava volcano? Why?

_____

_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 3.

Summary

You have come to the end of Lesson 3. In this lesson you have learnt that:

- a volcano is a conical hill or mountain formed by material from the mantle being forced through an opening or vent in the Earth's crust.
- many different materials are released by volcanic action, include lava, water, ash, rocks, gases and minerals.
- a tsunami is a large ocean wave usually caused by an underwater earthquake or a volcanic explosion.
- the ring of fire has 452 volcanoes and is home to over 50% of the world's active and dormant volcanoes.
- volcanoes can be active, dormant or extinct.
- volcanic eruptions can kill living things and destroy property, but they can also improve the fertility of the soil.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Answer the following questions.

1. Below are jumbled sentences. Rewrite the following sentence correctly.

   A. mantle come from the materials that build up volcanoes inside the
   _____
   _____

   B. is called inside the earth melted rock magma
   _____
   _____

   C. surface earth's is magma that flows over lava
   _____
   _____

   D. hardens igneous rock to form when magma or lava cools it.
   _____
   _____

2. Select from the following materials those that are most likely to come out of a volcano.
   (There may be more than one)

   A. rubber B. steam C. concrete
   D. rock fragments E. ash

3. How are magma and lava similar?
   _____
   _____

4. Describe how volcanic eruptions can affect the fertility of the soil.
   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

1. The area of the crust that is unstable is indicated by the changing land as a result of volcanoes, earthquakes and uplift.

2. A volcano is a conical hill or mountain formed by material from the mantle being forced through an opening or vent in the Earth's crust.

3. The materials released by volcanic action are; steam, gas filled magma, rock fragments, ash, froth, dust and smoke.

4. Magma is the molten rock when it is under the ground and lava is the molten rock flowing smoothly out of the volcano. Molten magma becomes lava when it reaches the surface.

5. Magma is found under the ground while lava is found on the surface of the ground.

6. An extinct volcano is a volcano that has not erupted for 25 000 years, while a dormant volcano is one that is not erupting at the moment but might erupt again.

7. I would prefer to live near an ash volcano because ash makes land very fertile.

Lesson 4: Types of Volcanoes

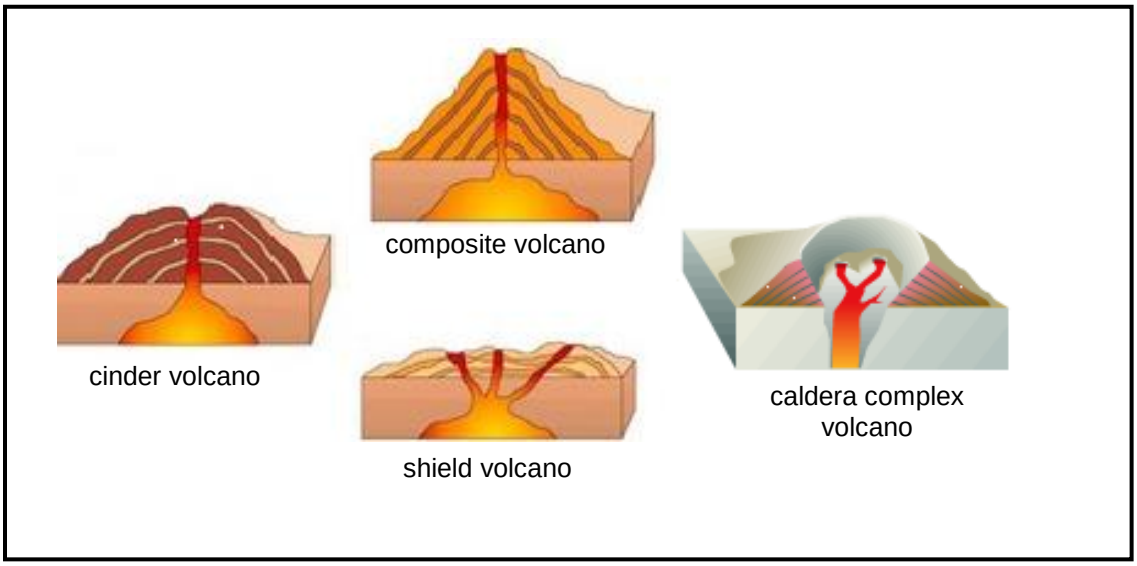
Welcome to Lesson 4. Do you still remember what you learnt in the last lesson? Yes, what a volcano is. You have learned so far that volcanoes have holes and cracks in the Earth from which molten rock (magma) and gas are produced. In this lesson you will learn about the different types of volcanoes.

Your Aims:

- describe the four types of volcanoes
- describe composite volcano.

Different Types of Volcanoes

There are four main types of volcanoes. These are; shield volcano, cinder cones, composite cone and caldera complex as shown in the diagrams below.



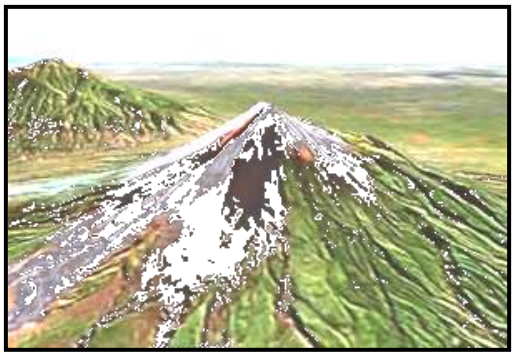
Schematic representation of the four types of volcanoes

Shield Volcano

One of the two most important types of volcanoes, are the shield volcanoes. They are large, broad and have relatively gentle **slopes***

The shield volcano is formed when lava flows out of a vent and spreads out over a wide area. The lava gradually builds up a broad shield-shaped cone with gentle slopes.

Eruptions on shield volcanoes are far less explosive than those on composite volcanoes. That is because the **basalt lava*** that erupts from shield volcanoes contains less silica, silicon dioxide, and is therefore less sticky (less viscous) and does not "plug up" the volcano.



The famous Mauna Loa, in Hawaii, is a shield volcano five kilometer wide.

Because the lava flows quickly, it travels farther from the crater before it cools causing the shield-like shape of the volcano as many eruptions build up over time.

Cinder cone on Mauna Kea, Hawaii

Cinder cone volcano

Cinder cones are circular or oval cones made up of small fragments of lava from a single vent that have been blown into the air, cooled and fallen around the vent.

A cinder cone volcano contains little or no lava. It is made up of mostly volcanic cinders and other pieces.

The cinders, which are large droplets of hardened lava, pile up close to the volcano opening to form a cone-shaped hill with steep sides and a narrow base. Because of the steep sides and loose material they erode easily.

Cinder cones are useful sources of landscaping material, like the lightweight frothy gravel used on running tracks or pathways. The industry calls it "lava rock" but geologists call it scoria.

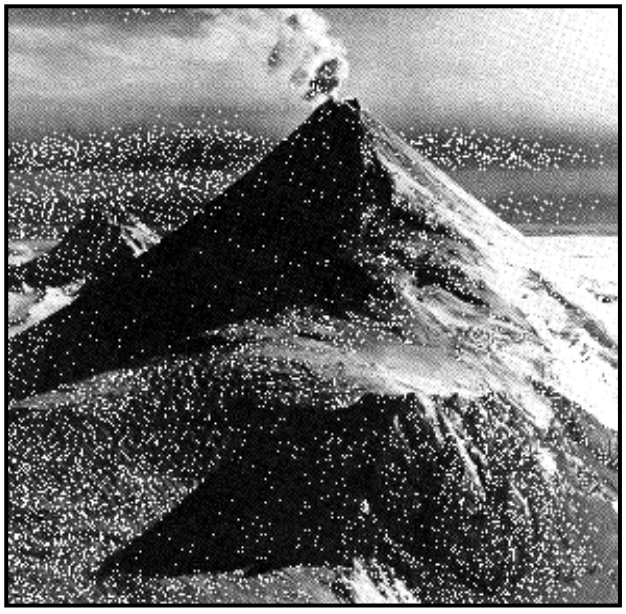
Composite volcano

Composite volcanoes (also called stratovolcanoes) are much more explosive than shield volcanoes, the other important type of volcano.

These are made of alternate layers of lava and cinders .The more lava in the cone, the greater its slopes and broader its base.

Composite volcano magma contains more silica, SiO_2, than that of a shield volcano and is therefore stickier (more viscous). This stickiness "plugs up" the volcano, causing pressure to build-up.

The result is an explosive and a dangerous eruption. Most of the world's great volcanoes are composites. They include Fujiyama in Japan, Vesuvius and Etna Italy, and Mount St. Helens in the United States.



Shishaldin Volcano, an imposing composite cone, towers 9,372 feet above sea level in the Aleutian Islands, Alaska.

Caldera complex volcano

Caldera is a cauldron-like volcanic feature usually formed by the collapse of land following a volcanic eruption. They are sometimes confused with volcanic craters. The word comes from Spanish caldera and from Latin caldaria, meaning "cooking pot". In some texts the English term cauldron is also used. **Rhyolite caldera complexes**, the most explosive of Earth's volcanoes.

These are volcanoes that often do not even look like volcanoes. They are usually so explosive when they erupt that they end up collapsing in on themselves rather than building any tall structure.

The collapsed depressions are called **calderas**, and they indicate that the magma chambers associated with the eruptions are huge.

Caldera complex forms from cinder cones. Cinder cones erode easily because of the steep sides and loose material and become caldera.

Rabaul Harbour formed from one very large crater

Rabaul in East New Britain is in a caldera. Rabaul Harbour is formed from one very large crater. The Harbour was formed when the top of a very large volcano was blown away during eruption many thousands of years ago.

Activity: **Now test yourself by doing this activity.**

1. Look at diagram A.

   a. What type of volcano is shown? _____.

   b. Explain your answer.

   _____

   _____

Diagram A

---

2. Rabaul Harbour in East New Britain is full of water. Explain how this might have happened?

   _____

   _____

   _____

   _____

   _____

3. Below are examples of volcanoes with descriptions. Complete the table by identifying what types volcanoes are these.

Examples	Description	Type of Volcano
Fujiyama in Japan	also called stratovolcanoes	
Mauna Kea, Hawaii	circular or oval cones made up of small fragments of lava	
Mauna Loa, Hawaii	eruptions are far less explosive	
Yellowstone, US	often don't like volcanoes	
Shishaldin, Alaska	explosive dangerous eruptions	

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 4.

Summary

You have come to the end of Lesson 4. In this lesson you have learnt that:

- scientists divided volcanoes into four main types; shield volcanoes, cinder cones, composite cones and caldera complexes.
- these are determined by the shape of the cone and the type of material they are consist of
- shield volcanoes are formed when lava flows out of a vent and spreads out over a wide area.
- a cinder cone volcano contains little or no lava.
- composite cones are made up of alternate layers of lava and cinders.
- when a crater collapses, it becomes a caldera.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

A. Encircle the letter of the correct answer.

1. An opening in the earth's surface through which molten rock flows is called a _____

   A. vent B. fault

   C. mantle D. caldera

2. The broad volcanic feature formed by quiet eruptions on thin lava flows is called a _____.

   A. rift B. cinder cone

   C. shield zone D. stratovolcano

3. When ash, cinders, and bombs build up in a steep pile around a volcano's vent, the result is a _____ volcano.

   A. shield B. cinder

   C. dormant D. composite

4. What is formed when a magma chamber empties and collapses?

   A. Vent B. Crater

   C. Caldera D. Fissure

5. Tall, cone-shaped mountains in where layers of lava alternate with ash are called _____volcanoes.

   A. shield B. cinder

   C. caldera D. composite

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

1. a. shield volcano
   b. You can tell from its broad shield-shaped and it is built of magma and lava.

2. The crater was filled with water when the top of the volcano was blown away that allowed water to enter.

3.

Examples	Description	Type of Volcano
Fujiyama in Japan	also called strato-volcanoes	composite
Mauna Kea, Hawaii	circular or oval cones made up of small fragments of lava	cinder cone
Mauna Loa, Hawaii	eruptions are far less explosive	shield volcano
Yellowstone, US	often don't like volcanoes	caldera complex
Shishaldin, Alaska	explosive dangerous eruptions	composite

Answers to Practice Exercises 1- 4

Practice Exercise 1

A.

Sun Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto

B.

1. Solar System

   This group of planets and their rotation or orbit around the sun is known as the Solar system.

2. Galaxy

   A galaxy is a collection of millions of stars, the planets, moons, asteroids or rocks, dust and gases gathered together as a group by a force

3. Universe

   The universe is very, very big. It is made up of billions of galaxies.

Practice Exercise 2

1. (D.) liquid at high temperature.
2. (B.) crust
3. (D.) asthenosphere
4. (A.) Outer core
5. (A.) iron and nickel

Practice Exercise 3

1. A. The materials that build up volcanoes come from inside of the mantle.

   B. Melted rock is called magma inside the earth.

   C. Lava is magma that flows over the earth's surface.

   D. When magma or lava cools it hardens to form igneous rock.

2. B. steam D. rock fragments E. ash

3. Magma is the molten rock when inside the earth, but as soon as this molten rock flows over the earth's surface it cools to become lava.

4. The volcanic eruptions deposit ash which makes soil very fertile.

Practice Exercise 4

1. (A.) vent
2. (D.) stratovolcano
3. (B.) cinder
4. (C.) Caldera
5. (D.) composite

REVISE TOPIC 1 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 1: Earth and Atmosphere

Now, revise all lessons in this Topic and then do **ASSIGNMENT 1.** Here are the main points to help you revise.

Lesson 1: The Planet Earth

- There are nine planets; Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Earth is the third planet from the sun.
- This group of planets and their rotation or orbit around the sun is known as the Solar system.
- A galaxy is a collection of stars, planets, moons, asteroids, dust and gases gathered together by gravity.
- Our solar system belongs to the galaxy called the, Milky Way
- There are billions of other galaxies, all of this make up the universe.

Lesson 2: The Interior and Exterior of the Earth

- The earth consists of the four concentric layers which are the outer and inner core, the mantle and the crust.
- The inner part of the earth is the core. The core is a dense ball of the elements iron and nickel. It is divided into two layers, the inner core and the outer core.
- The layer above the core is the mantle. It is the widest section of the Earth. It has a thickness of approximately 2,900 km
- Asthenosphere is the tough liquid part of the outer mantle.
- Lithosphere is the stiffer part of the outer mantle and the crust. The lithosphere 'floats' on the asthenosphere, like ice on water.
- The crust covers the mantle and is the earth's hard outer shell, the surface on which we are living.
- The crust consists of two parts: the oceanic and the continental crust.

Lesson 3: Volcanoes

- The Earth may be divided into active and stable areas.
- Volcanoes and earthquakes can be found in active areas.
- Many different materials are released by volcanic action, this include; lava, water, ash, rocks, gases and minerals.
- Volcanoes can be active, dormant or extinct.
- Volcanic eruptions can kill living things and destroy property, but they can also improve the fertility of the soil.

Lesson 4: Types of Volcanoes

- Scientists divided volcanoes into four main types; shield volcanoes, cinder cones, composite cones and caldera complexes.
- These are determined by the shape of the cone and the type of material they are built of.
- Shield volcanoes are formed when lava flows out of a vent and spreads out over a wide area.
- A cinder cone volcano contains little or no lava.
- Composite cones are made up of alternate layers of lava and cinders.
- When a crater collapses, it becomes a caldera.

NOW DO TOPIC TEST 1 IN YOUR ASSIGNMENT 6.

TOPIC 2

ROCK CYCLE AND WEATHERING

In this topic you will learn about:

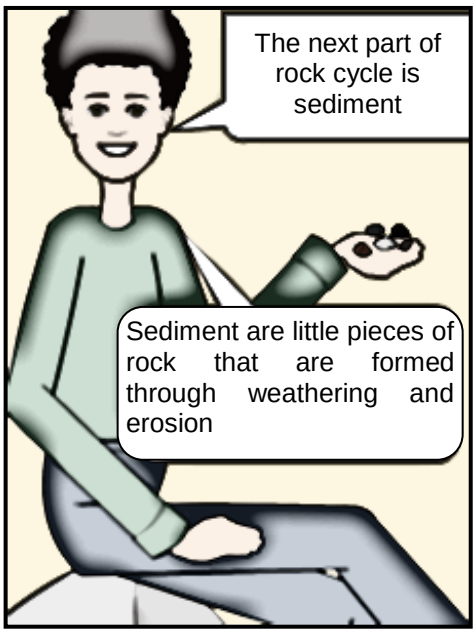
- **sedimentary rocks**
- **igneous rock**
- **metamorphic rock**
- **physical weathering**
- **chemical weathering**

INTRODUCTION TO TOPIC 2: ROCK CYCLE AND WEATHERING

Rocks, soils, fossils and the Earth's crust make up the foundation of the world we depend upon. Engineers must understand the characteristics of these rocks and materials so that they can design big infrastructure projects such as bridges, foundations, roads and tunnels to be safe and long lasting. They apply their understanding of rocks to environmental site investigations for the purpose of land development and environmental preservation. That is to prevent and limit the destruction of communities and human life and also to develop technologies to take measure and predict natural hazards caused by rock movement.

The rock cycle is the one of the great cycles on the planet. The rock cycle has no beginning or no ending, but is an endless process. One of the most important aspects of the rock cycle is weathering.

Weathering is an essential Earth process. Weathering changes rocks from a hard state to become much softer and weaker, causing them to be more easily eroded. This is one of the processes that continually shape the Earth's surface and generate the sediments that circulate in the Rock Cycle. Landforms are the result of the interactions among the lithosphere, atmosphere and hydrosphere.



Topic 2 looks at the three types of rocks: sedimentary, igneous and metamorphic. It looks at how they are formed, the weathering of rocks and the way one form of rock turns into another, in the rock cycle.

Following are some questions you may be asking yourself now.

- How do rocks become soil?
- What are different types of rocks?
- How are different rocks formed through the Rock Cycle?
- What is weathering and erosion?

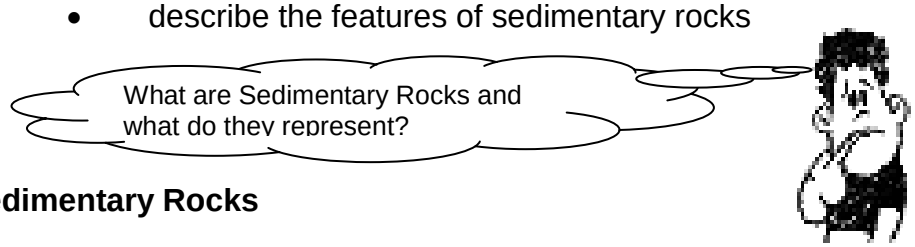
In this Topic, you will find the answers to these questions and all other questions relating to rock cycle and weathering.

Lesson 5: Sedimentary Rocks

Welcome to Lesson 5. Do you still remember what you learnt in the last lesson? Yes of course, it was about volcanoes. Molten rock or magma is a product of a volcanic activity. Igneous rock, one of the three types of rock, is formed when the molten magma cools and solidifies or becomes solid. Sedimentary rock is another rock type out of the three. Deep underground igneous and sedimentary rocks can be changed by either heat or pressure or both. They become metamorphic or 'changed' rock. Igneous and metamorphic rock types will be learned in the next two lessons. For this lesson you will study more about sedimentary rocks.

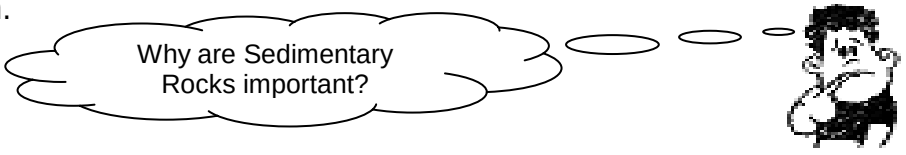
Your Aims:

- identify sedimentary rocks
- explain the formation of sedimentary rocks
- describe the features of sedimentary rocks



Sedimentary Rocks

Sedimentary rocks are rock particles and mineral grains (sediments) deposited in a fluid (water or air) and subsequently transformed to rocks ("lithified"). They typically occur in layers (strata) separated by bedding plains and differences in composition. Seventy five percent (75%) of all rocks exposed at Earth's surface are sedimentary rocks. Sedimentary rocks are those that represent the material record of environments in the form of rock layers or strata that once existed on earth.



Sedimentary rocks contain information about what earth surface environments were like in the past. They preserve a record of ancient landscapes, climates and mountain ranges as well as the history of the erosion of our region and possess natural resources including important fossil fuels.

Many fossils are found in sedimentary rocks younger than 600 million years and provide evidence of the evolution of life through time.

Sedimentary environments which are depositional environments are places where sediments accumulate usually in nearly horizontal layers.

There are three (3) very general sedimentary environments. They are:

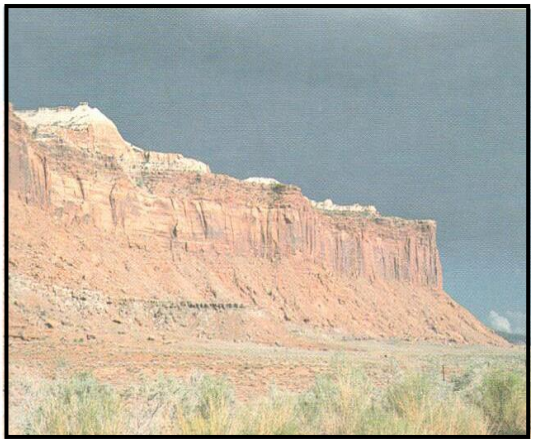
- Continental or landmass
- Near shore or shallow water. This a transition between continental and ocean
- Deep marine water

Identification and Formation of Sedimentary Rocks

Sedimentary rocks are formed from layers of sediments deposited by seas, rivers, wind, or glaciers. The sediments are composed as more and more material collects above them. Then they harden and set like concrete. This process can take millions of years. The layers of rock are called **strata**.

Most sediments are fragments of eroded rock. However, some are bits of shells and skeletons from tiny sea creatures which lived millions of years ago. Limestone, which is mainly calcium carbonate, is usually formed from bits like this. But, it can also be formed in another way. Sea water contains dissolved **calcium carbonate**.* When warm, shallow seas evaporate, the solid is deposited, rather like the scale in a kettle.

This limestone formed from the shells and skeletons of ancient, tiny sea creatures



This sandstone formed from fragments worn away from other rocks.

What are the processes that are involved in the formation of sedimentary rocks?

All of the processes that are involved in the formation of sedimentary rocks are collectively referred to as **diagenesis**. It may occur at or very near surface, but more commonly occurs after sediments are buried.

Diagenetic Processes

Sedimentary rock formation begins with igneous, metamorphic, or other sedimentary rocks. When these rocks are exposed at the earth's surface they begin the long slow but relentless process of becoming sedimentary rock**.**

Sedimentary rocks are the product of:

1) **weathering** of pre- existing rocks,
2) **transport** of the weathering products,
3) **deposition** of the material,
4) **compaction** and
5) **cementation** of the sediment to form a rock.

The last two steps, 4 and 5 are called **lithification.**

Weathering

All rocks are subject to weathering. **Weathering** is anything that breaks the rocks into smaller pieces or sediments. This is caused by the forces of like wind, rain, and freezing water.

Large amounts of broken- down rock may be eroded and collect in areas where they can be cemented together to form new rocks. These rocks are called sedimentary rocks. Movements in the earth may push these up, and the process of weathering and erosion will start again.

Erosion is the movement of sediment or soil from one location to another by means of water, ice or wind or it may also involve the combination of weathering and movement of the resulting sediments.

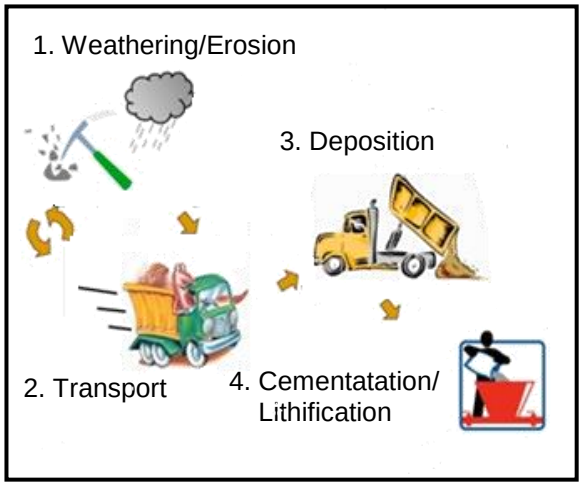
Transport and **depositio**n bring these small pieces of rock into an area where there are many similar pieces of rock being dropped or deposited. There needs to be deposits of sediments before sedimentary rocks are formed.

As the process of weathering continues the products are carried off. The sediments that form from these actions are often carried to other places by the wind, running water, which is the most important transporting agent and gravity. Gravity pulls sediment down steep slopes through creep, rock or debris falls, landslides and slumps. As these forces lose energy the sediments settle out of the air or water. As the settling takes place the rock fragments are graded by size. The larger heavier pieces settle out first. The smallest fragments travel farther and settle out last. This process of settling out is called **deposition**.

Lithification is the changing of sediments into rock. There are two processes involved in this change. They are **compaction** and **cementation**.

Compaction and **cementation** is what turns sediment into sedimentary rock. Over time, sediment accumulates in oceans, lakes, and valleys, eventually building up in layers and weighing down the material underneath. This weight presses the sediment particles together, **compacting** them.

Cementation happens as dissolved minerals become deposited in the spaces between the sediments. These minerals act as glue or cement to bind the sediments together.



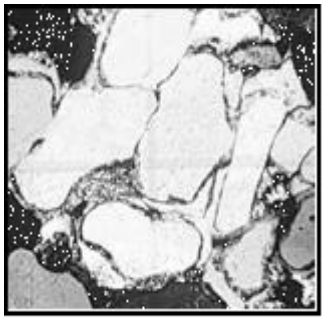
Diagenetic processes

Features of Sedimentary Rocks

Sedimentary rocks have the following features:

1. Sedimentary rocks usually have a layered structure. Layers maybe built up as the particles, are deposited from water or air. These are called sedimentary beds (strata).

2. Plant and animal remains maybe trapped in sedimentary rocks. These are called fossils. Fossils are very important because they help to determine the age of the rocks and show what the environment was like in the past.
3. Sedimentary rocks are made of particles that show the effects of erosion. This explains that the distance that the particles have been carried from where the weathering took place. They may be smooth and rounded or irregular in shape. The greater the distance transported, the rounder the particles become.



Grains become cemented together

Classifying Sedimentary Rocks

Sedimentary rocks are classified according to the way they are formed and of what they are made.

The **origin** of a rock refers to the way the rock was formed. Conglomerates, breccia, sandstones and mudstones are formed in this way.

The **composition** of a rock describes the parts that make up the rock. A sedimentary rock can have three major parts. When a sedimentary rock is forming, very small-grained material about the size of the sugar **crystals*** may fill the spaces between the larger particles. The larger particles are called the **grains,** and the small-grained material is called the **matrix**. A **cement** material then holds the rocks together.

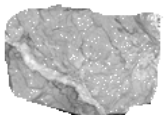
Uluru consists of nearly vertical beds of sandstone and is the remains of a mountain range.

The **cement** found in sedimentary rocks may be of many types. The most common are silica, iron and calcium cements. Calcium cements are found in limestone. Sandstones are usually cemented by silica, but can be cemented by iron.

Sedimentary rocks may be given names based on the **size of the grains**. Small – grained rocks are called **mudstones**. Slightly larger grains form a siltstone. **Sandstone** is formed when grains are between 0.2 and 2mm in diameter .Uluru which is a huge rock made of sandstone is one of the most famous features in Australia.

Sedimentary rocks can also be classified based on the **shape of the grains**. The longer the grains are transported they tend to become rounded and more like the shape of the ball. Angular shape for grains which have not been transported that far. Uluru has sharp, angular grains while beach sand has smooth, rounded grains.

If beach sand is observed under a microscope it will be seen consist of well-rounded particles. Long-term weathering and erosion produce these smooth shapes. Conglomerate is a rock which has well-round pebbles cemented together.

Common Names	Sample Image	Description
Limestone		Usually formed in the sea.
Sandstone		Usually formed on land or near the coast. Contains a lot of quartz.
Conglomerate		Has rounded pebbles in small-grained material. Usually formed in rivers.
Breccia		Has an angular particle in small-grained material. Formed from broken rock cemented together.
Fossil limestone		Usually have many marine animals' remains such as coral and shells.
Shale		Very small-grained rock. A microscope is needed to see the grains.
Siltstone		Small –grained material. Feels slightly rough.

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

Use the words in the boxes to answer **Questions 1& 2**

Magma	strata	lava

1. Which of the above words means
   a) Layers of rock? _____
   b) Molten rock from a volcano _____
   c) Molten rock in the earth's mantle _____

sedimentary	metamorphic	igneous

2. Which of the above rocks are formed?
   a) From materials deposited by water or wind? _____
   b) When molten magma cools and solidifies? _____
   c) By the action of heat or pressure on existing rocks? _____

3. How can you identify the features of a sedimentary rock?
   _____
   _____

4. What is the difference between breccia and conglomerate?
   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 5.

Summary

You have come to the end of Lesson 5. In this lesson you have learnt that:

- sedimentary rocks are formed from layers of sediment deposited by seas, rivers, wind, or glaciers.
- most sediments are fragments of eroded rock.
- the layers of rock in sedimentary are called strata/sedimentary beds.
- broken-down rock produces sediment which may become a sedimentary rock.
- sedimentary rocks usually have layers and often contain fossils.
- sedimentary rocks are classified by their origin, composition, grain size and shape.
- sedimentary rocks have different kinds of cementing material.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Choose the letter of the best answer.

1. Which of the following processes does not occur during diagenesis?

   A. Compaction
   B. Cementation
   C. Lithification
   D. Metamorphism

2. Shale refers to a rock formed from

   A. carbonate
   B. plant remains
   C. clay minerals
   D. sand sized material

3. Which one of the following features is NOT associated with sedimentary ?

   A. Rocks
   B. Fossils
   C. Bedding
   D. Foliation

4. Which of the following types of currents can transport sand grains?

   A. Wind
   B. Rivers
   C Ocean waves
   D. All of these

5. Which of the following lists is written in order of decreasing particle size?

   A. Sandstone, siltstone, conglomerate
   B. Sandstone, conglomerate, siltstone
   C. Conglomerate, sandstone, siltstone
   D. Siltstone, sandstone, conglomerate

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

1. a) strata
   b) lava
   c) magma

2. a) sedimentary
   b) igneous
   c) metamorphic

3. Sedimentary rocks usually have a layered structure. Layers maybe built up as the particles are deposited from water or air, These are called sedimentary beds (strata).

4. Conglomerate is a rock which has well-rounded pebbles cemented together where breccia is the type of sedimentary rock formed from small pieces of broken rock cemented together.

Lesson 6: Igneous Rocks

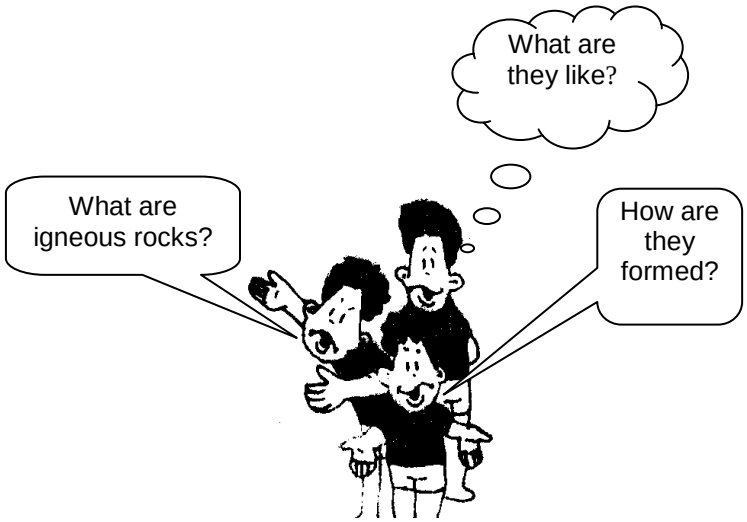
Welcome to Lesson 6. Do you still remember what you learnt in the last lesson? There are three main types of rocks. You have studied one of them already in the previous lesson, sedimentary rocks. In this lesson we are going to look at the second type of rock called the igneous.

Your Aims:

- identify igneous rocks
- describe the features of igneous rock
- explain the formation of igneous rocks

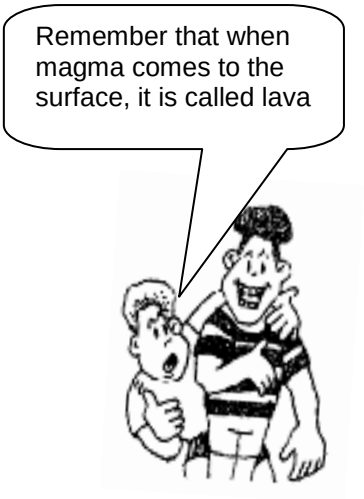
Igneous Rock

Igneous rock is the oldest type of rock. Igneous rocks are called **fire rocks** and are formed from melting rocks.



Igneous rocks contain randomly arranged crystals. The size of the crystals depends on how quickly the molten magma solidified. The more slowly the magma cools, the bigger the crystals.

Deep inside the earth, the temperature is very, very high and the minerals there have melted into liquid form called magma. Because it's so hot, any rocks that are down in that core are liquids. As the magma is pushed towards the surface of the earth, it starts to cool and turns into solid forming igneous rocks.



But sometimes these liquid rocks called magma shoot up to the surface when volcanoes suddenly erupt. Then tonnes of liquid rock rocket out of the top of the volcano and land on the surface. When the liquid rock cools down, it becomes igneous rock.

Igneous rocks are formed when magma cools down, but they do not cool down the same way. Some cool slowly, while others cool very quickly forming the different types of igneous rocks. Those that form deep within the Earth's crust where temperatures are very high might take thousands of years to cool down. This causes the crystals to be much larger, such as in the case of granite. Igneous rocks formed on the surface cool down in just a matter of a few hours. The key factors to use in determining which rock you have are the **texture** and **composition** of the rock.

Texture relates to the size of the individual mineral grains in the final, solid rock. In most cases, the resulting grain size depends on how quickly the magma cooled, and in general, the slower the cooling, the larger the crystals in the final rock.

There are **two types** of igneous rocks based on the texture.

1. **Intrusive igneous rocks** sometimes also known as **plutonic rocks** are the coarse grained rocks in that they are slowly cooled and formed by solidifying of magma at depth in the crust of the earth, where they are insulated by layers of rock and sediment. The slow cooling formed large crystals.

Granite is an example of an intrusive igneous rock

White crystals are formed on this granite rock when it cooled slowly.

Granite rock can be used for gravestones or polished to make a very attractive countertop.

Activity 1.1: **Now test yourself by doing this activity.**

Fill in the missing information.

1. Igneous rocks are divided into _____types.
2. Intrusive rocks are also known as_____.
3. Intrusive rocks are found deep _____the earth's surface.
4. They were formed by the slow _____and _____of magma under the earth's crust.

---

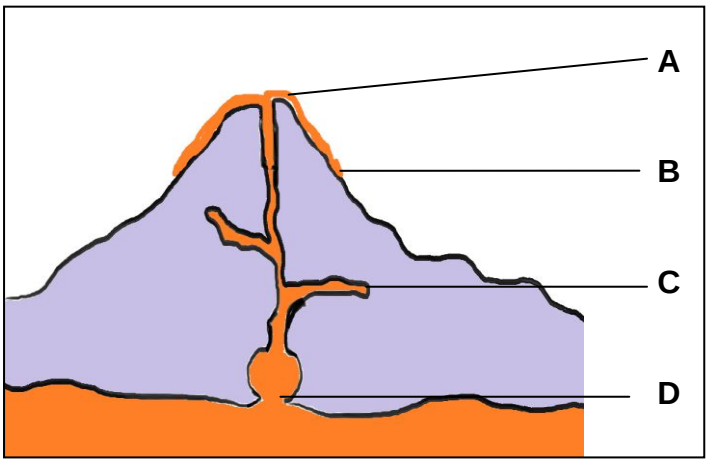
2. **Extrusive igneous rocks** also called as **volcanic rocks.** They are fine grained rocks or have very small crystals, generally produced in volcanic eruptions. They are formed when magma under the earth's crust or surface is poured out onto the earth's surface as lava. This normally happens when volcanoes erupt. The lava cools very quickly resulting in the formation of the extrusive igneous rocks being formed.

Basalt rock is an example of an extrusive igneous rock with very small crystals because the lava cooled very quickly at the surface. Basal makes up much of the bedrock of the ocean floor.

Basalt rock with crystals which cannot be seen because they are very small.

Activity 1.2: **Now test yourself by doing this activity.**

Refer to the diagram below to do this activity.
Write the letter that represents the correct place where you would find the following:



1. magma _____
2. lava _____
3. intrusive rocks _____
4. extrusive rocks _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 6.

So we see that the texture of igneous rocks is one way to classify them, but they are also classified by the minerals they contain. The other factor to consider in classifying igneous rocks is their **composition.**

The elements in the magma directly affect which minerals are formed when the magma cools. Magma can be composed of different minerals and therefore solidify into rocks with different mineral compositions. There are countless intermediate compositions, but again we will only describe the extremes.

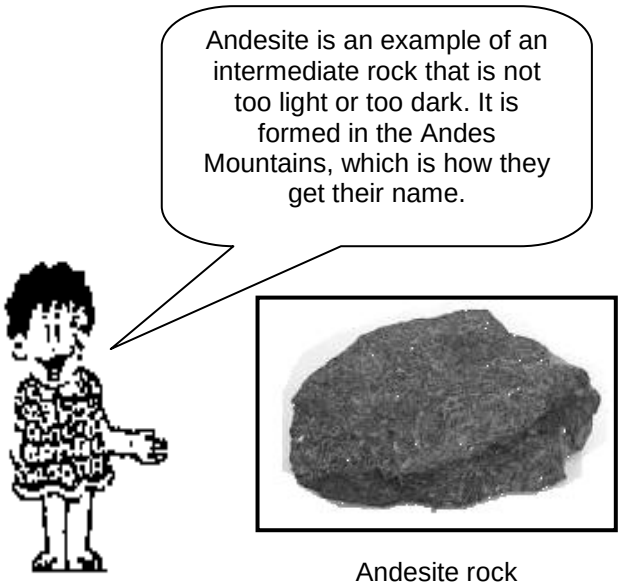
1. **Felsic Rocks**
   Let us start with felsic rocks, which are light-colored and not very dense rocks that contain a lot of feldspar and quartz.

   Quartz is a hard mineral composed of large amounts of a compound called **silica**. These rocks get their name from the combination of 'fel' plus 'sic,' which is basically an abbreviated form of 'feldspar' plus 'silica.' Granite is an example of felsic rock.

2. **Mafic Rocks**
   Mafic rocks are denser and darker in colour that contains a lot of magnesium and iron. These rocks get their name from the combination of “ma” an abbreviated form of magnesium plus “ferric” which means contain iron with the symbol of Fe. A common example of this rock is basalt

3. **Intermediate Rocks**
   Of course, some rocks are in between light and dark colour and share minerals of both felsic and mafic rocks. These rocks are called intermediate.

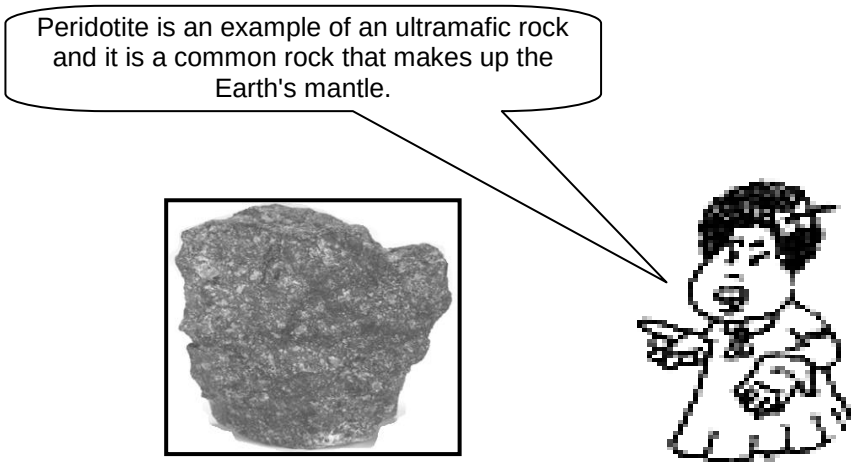
   The Andes is known for its long mountain range that travels along the west coast of South America, but it is also known for its volcanoes, which is where we get these intermediate rock.



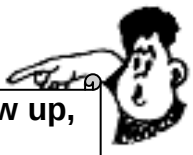
Andesite rock

4. **Ultramafic Rocks**
   Other rocks may contain mainly of magnesium and iron and very little silica.

   If you can recall, magnesium and iron are mafic minerals, so ultramafic igneous rocks are like super-charged mafic rocks, kind of like Ultra-Frisbee is super-charged Frisbee. And because ultramafic rocks contain very little silica, they are pretty different from felsic rocks, which contain a lot of silica or quartz.



Peridotite



Granite and Basalt are born from magma, but after they grow up, they do not have a lot in common.

Summary

You have come to the end of lesson 6. In this lesson you have learnt that:

- igneous rock is formed when magma cools and solidifies either above the earth's crust or beneath it.
- there are two main types of igneous rocks; intrusive and extrusive rocks.
- intrusive igneous rocks are formed under the earth's crust and cools slowly forming large crystals. Granite rock is an example of an intrusive rock.
- extrusive igneous rocks are formed above the earth's surface therefore it cools very quickly forming very tiny crystals. Basalt rock is an example of extrusive igneous rocks.
- composition is another way to classify igneous rocks. The composition of the rocks is determined by the minerals that make up the magma from which they form.
- felsic rocks are light-colour rocks that contain a lot of feldspar and quartz.
- mafic rocks are dark-colour rocks that contain a lot of magnesium and iron.
- intermediate rocks are appropriately named because they are rocks that are between light and dark colour and share minerals with both felsic and mafic rocks.
- there are also ultramafic rocks, which are rocks that contain mainly magnesium and iron and very little silica. Because they have mostly mafic minerals, they are like super-charged mafic rocks - in other words, ultramafic.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

A. Write one or two word answers for the following questions on the space provided.

1. What type of igneous rocks formed above the earth's crust? _____
2. Give one example of an extrusive igneous rock. _____
2. What type of igneous rocks formed below the earth's crust? _____
3. Name the molten rock under the earth's surface. _____
4. Name molten rock above the earth's surface. _____

B. Explain the following items.

1. How are igneous rocks formed?

_____
_____
_____

2. Explain the difference between intrusive and extrusive rocks.

_____
_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activities

Activity 1.1

1. two
2. plutonic rocks
3. under
4. cooling, solidifying

Activity 1.2

1. D
2. A
3. C
4. B

Lesson 7: Metamorphic Rocks

Welcome to Lesson 7. From our previous lessons you have looked at the sedimentary and igneous rocks and how they are formed. In this lesson we will look at the last type of rocks, the **metamorphic** rocks. We will also look at how rocks are constantly being formed, worn and broken down and then formed again. This is known as the **Rock Cycle.**

Your Aims:

- identify metamorphic rocks
- explain the formation of metamorphic rocks
- describes the features of metamorphic rocks
- explain the rock cycle.

What are Metamorphic Rocks?

Metamorphic rocks are the most difficult to understand and to identify. Metamorphic rocks are all around us. We use them from everything from old fashion chalk boards to decorative rocks around our homes. These rocks were formed inside the Earth's crust or near the surface along fault zones. Metamorphic rocks are easy to identify in nature, when you see squashed, deformed rocks. Hand samples are more difficult.

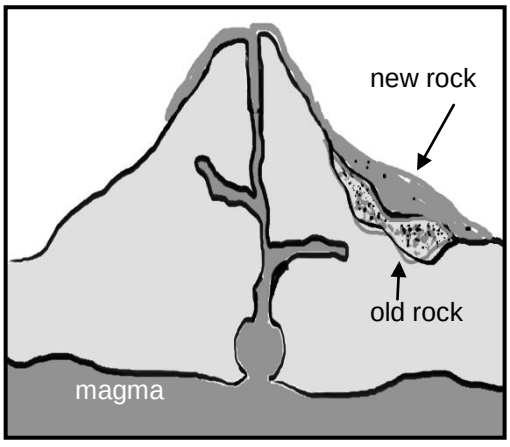
Have you heard that caterpillars change into butterflies? Well, rocks can change too! They don't grow wings like a butterfly. But they do change! Sedimentary rocks and igneous rocks change when they are in a place that is very hot and pressure is high. This pressure and high temperature cause them to change their form and become metamorphic rocks.

Metamorphic rocks are rocks that have changed. The word comes from the Greek "meta" and "morph" which means to change form. Metamorphic rocks were originally igneous or sedimentary, but due to high temperature and pressure, they were changed. The process of changing is called **metamorphism.**

Formation of Metamorphic Rocks

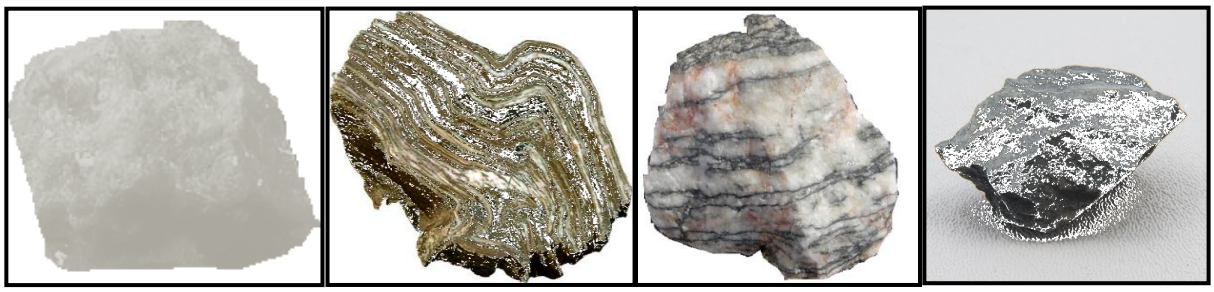
Metamorphic rocks form deep within the Earth when heat and pressure are applied to either igneous rocks or sedimentary rocks. This heat and pressure cooks the rocks, changing their structure. The rocks are partially melted and the chemicals within them are rearranged so that the final rock is very different than the original rock.

The final state of a metamorphic rock depends on the amount of pressure and heat the rock was subjected to, and the amount of time the rock was subjected to pressure and heat.



New rock buries old one

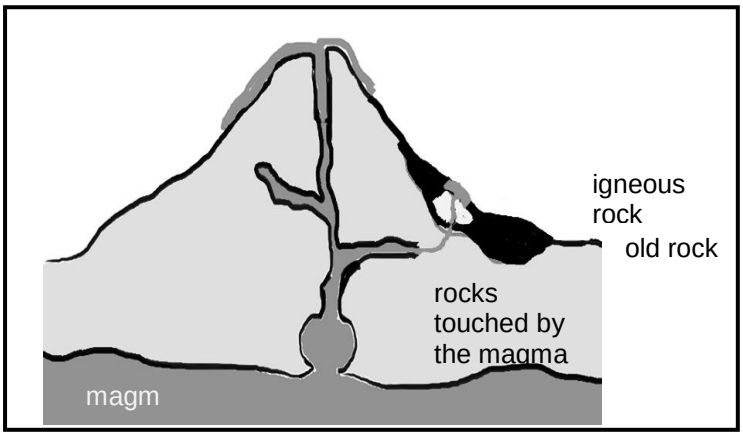
Some common metamorphic rocks are marble. Marble is formed when heat and pressure are applied to limestone for many thousands of years. Schist, slate, gneiss (pronounced "nice").All of these rock types are formed by heat and pressure.



Marble Schist Gneiss Slate

Two Different Ways Rocks Can Undergo Metamorphism

1. **Contact metamorphism** occurs when igneous and sedimentary rocks are heated as they come in contact with molten magma. These metamorphic rocks are usually found around the edges of igneous rock formations. Most contact metamorphic rocks are called **hornfels**.



Any rock touched by magma can change

2. **Regional metamorphism** occurs when rocks over a large area are exposed to great heat and pressure. Most regional metamorphism occurs due to deep burial or to movements of rock in the crust.

Features of Metamorphic Rocks

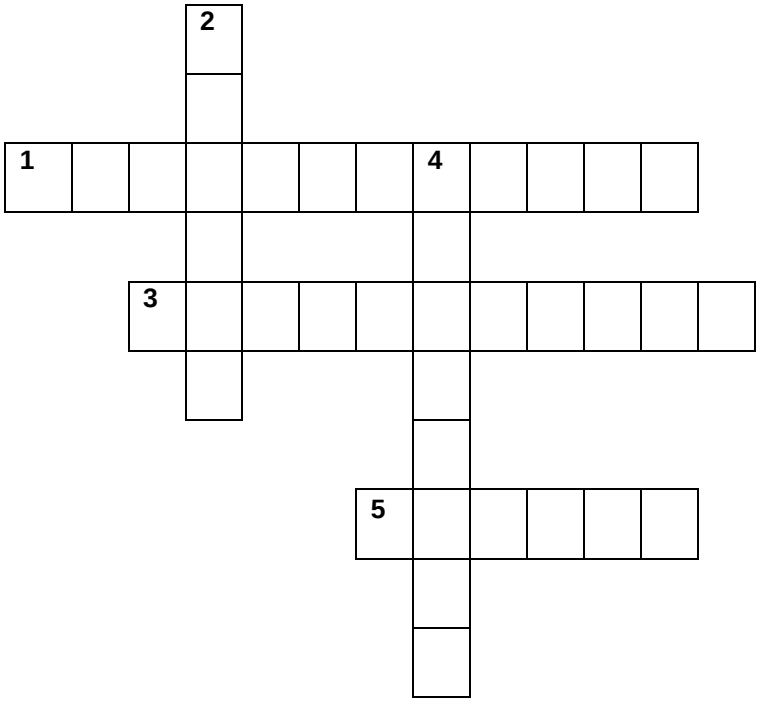
Metamorphic rocks have certain features which set them apart from other rocks.

1. All metamorphic rocks have crystalline structure. Many have needle-like crystals arranged in parallel layers.
2. Many contain unusual minerals that are only formed under high temperatures and pressures.
3. Metamorphic rocks formed from sedimentary rocks may have distorted layers. Some becomes denser as a result of great pressure upon them.
   Pressure squeezes rock molecules to pack closer together resulting in rock mass being forced into a smaller volume.

You may want to have several samples of metamorphic rocks and the rocks they changed from. A gneiss could have come from a granite (igneous). Shale (sedimentary) could have become slate. Slate (metamorphic) if put under more pressure could change into a schist. A basalt (igneous) could also become a schist.

Activity1.1: Now test yourself by doing this activity.

Complete the puzzle below.



Clues
1. The process of changing.
2. Large moving _____ makes up the earth's crust.
3. Metamorphic rocks were previously either igneous or _____ rocks.
4. Heat and _____ changes sedimentary and igneous rocks to metamorphic rocks
5. The main type of metamorphism in rocks occurs when rocks are _____by new rocks formed on top of them.

The Rock Cycle

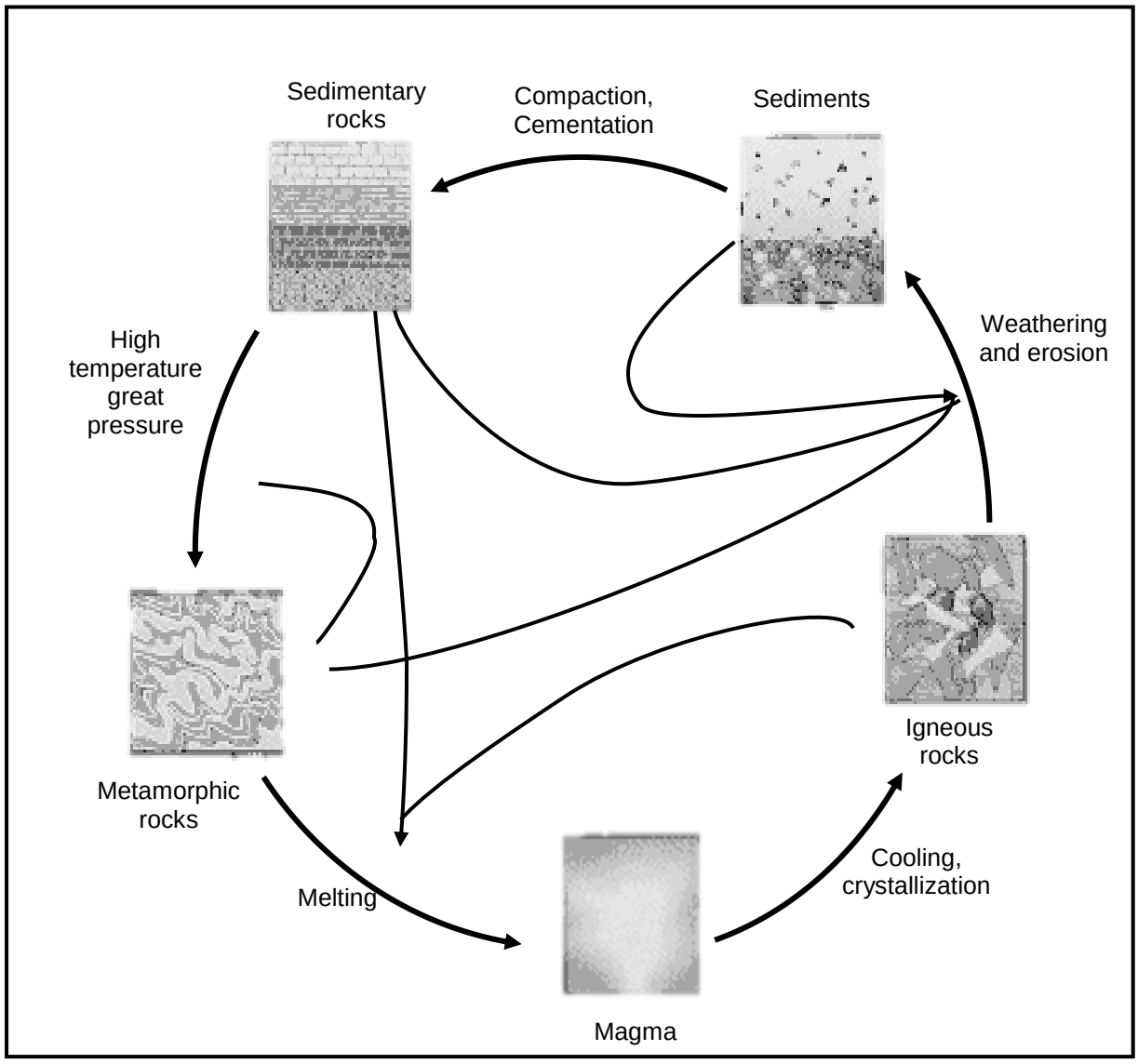
The Earth's rocks do not stay the same forever. They are continually changing because of processes such as weathering and large earth movements. The rocks are gradually recycled over millions of years. This is called the rock cycle.

For example sedimentary rocks can be changed into metamorphic rocks and these can be weathered and the pieces transported away. These pieces could be deposited in lakes or seas and eventually form new sedimentary rock. Many ways through the rock cycle are possible.

1. Weathering breaks down rocks on the surface of the Earth. Wind and water move the broken rock particles away. This is called erosion. Rivers and streams transport rock particles to other places.

2. Rock particles are deposited in lakes and seas where they build up to form layers. This starts the process of sedimentation which will create **sedimentary rock.**
3. Rocks underground that get heated and put under pressure are changed into metamorphic rock and rocks underground that get heated so much they melt and turn into magma.
4. Pressure can force magma out of the ground. This creates a volcano. When the magma cools, it turns into solid rock called **extrusive igneous rock**. Magma that cools underground forms solid rock called **intrusive igneous rock**.
5. Areas of rock can move slowly upwards, pushed up by pressure of the rocks forming underneath. This is called uplift.

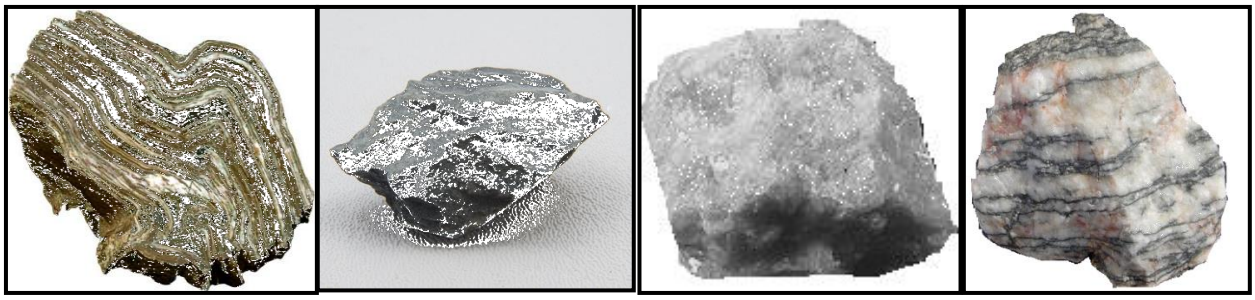
The cycle goes on very slowly for millions of years and it is still happening today.
The processes in the rock cycle are shown in this diagram. Use your fingers, trace through the cycle. Make sure that you understand and follow through.



The rock cycle

Activity 1.2: **Now test yourself by doing this activity.**

Without looking at your previous notes, see if you can name these metamorphic rocks correctly.



1. _____ 2._____ 3._____ 4._____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 7.

Summary

You have come to the end of lesson 7. In this lesson you have learnt that:

- metamorphic rocks are igneous or sedimentary rocks that have been transformed by great heat or pressure.
- this heat and pressure melts the rocks, changing their structure.
- rocks can be changed to metamorphic rocks when: they are buried by new rocks or formed from the pressure and heat caused by the earth's plates crashing into each other or when magma passes through cracks in rocks.
- marble, schist, slate and gneiss are examples of metamorphic rocks.
- the rocks are recycled over millions of years. This is called the rock cycle.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Explain the following.

1. Explain how metamorphic rocks are formed?

_____
_____
_____
_____
_____

2. Explain in your own words the three ways that rocks can be changed by heat and pressure.

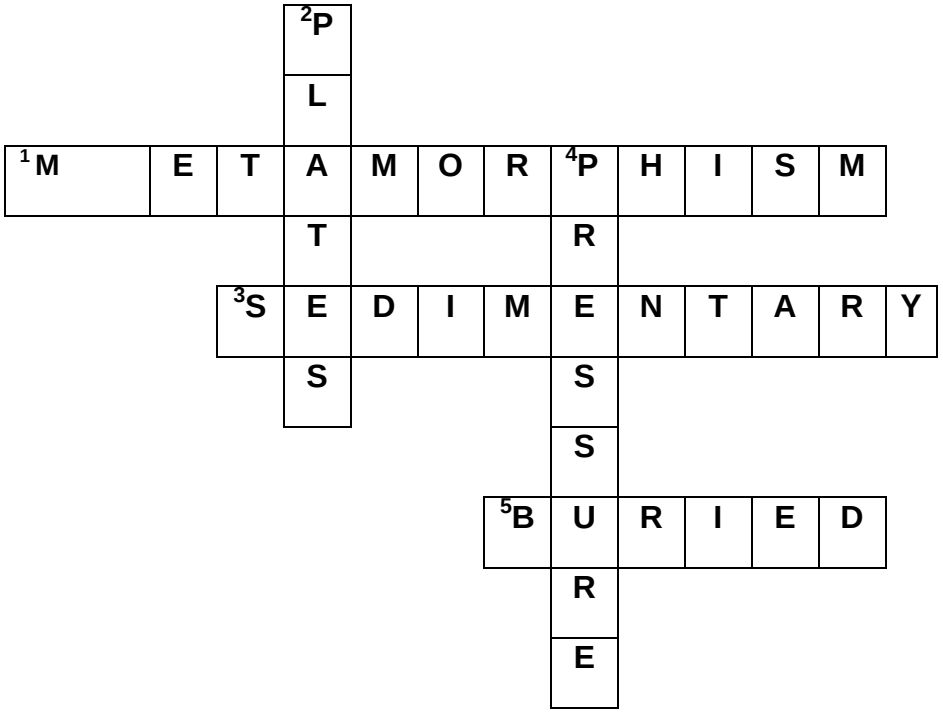
_____
_____
_____
_____
_____
_____
_____
_____

3. Draw a simple rock cycle below by putting in the following details. (weathering, erosion, magma, igneous rocks, sedimentary rocks, metamorphic rocks.)

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activities

Activity 1.1



Activity 1.2

1. Schist
2. Slate
3. Marble
4. Gneiss

Lesson 8: Physical Weathering

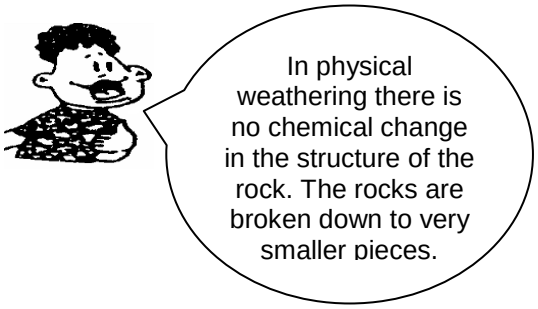
Welcome to Lesson 8. As you will recall the rock cycle from our last lesson, weathering breaks down rocks on the surface of the Earth. Wind and water move the broken rock particles away into the rivers. The rivers and streams transport rock particles to other places and new rocks are formed. Well, in this lesson we will look more closely at the process of weathering.

Your Aims:

- define weathering and physical weathering
- identify example of physical weathering
- state the rates and effects of physical weathering

Two Kinds of Weathering

Every single rock on the surface of the Earth is slowly being broken down. This breaking down of rocks at or near the Earth's surface is called **weathering**. The word weathering is used because the weather is mainly responsible for breaking and making the pieces of rock smaller and smaller. There are two kinds of weathering; **chemical weathering and physical weathering.** We will first discuss physical weathering.



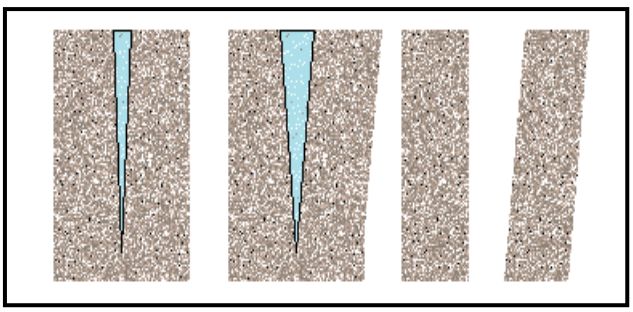
Physical weathering is the breakdown of rocks due to the direct contact with earth's forces. It is caused by physical changes such as changes in temperature, freezing, the effects of wind, rain and waves and plants and animals. Wind, rain, waves and all those factors that cause physical weathering are known as agents.

Below are some common agents of weathering.

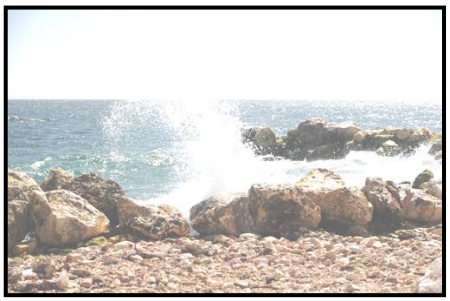
1. **Temperature**
   When a rock gets hot it **expands** a little. This expansion increases the size of the rock. When a rock gets cold it **contracts** a little or gets small in size. If a rock is heated and cooled many times, cracks form and pieces of rock fall away. This type of physical weathering happens a lot in deserts, because it is very hot during the day but very cold at night.

2. **Frost or Ice Action**
   When water freezes its volume increases. This process occurs when the water inside of rocks freezes, it expands. That expansion cracks the rocks from the inside and eventually breaks them apart.

FROST ACTION



3. **Wind, Rain and Waves**
   Wind, rain and waves can all cause weathering. The wind can blow tiny grains of sand against a rock. These wear the rock away and weather it. Rain and waves can also wear away rock over long periods of time.

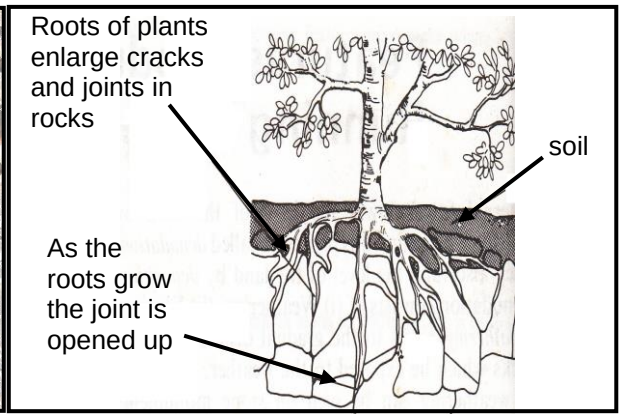


Rocks broken down by wave action

4. **Plant and Animal Action**
   Plants and their roots also push into the rocks and break them apart.

   They act like wedges and push the rocks apart. Little animals also help by burrowing and digging through the ground.

Part of the rock formation being broken by the tree



Weathering by the action of plant roots

Effects of Physical Weathering

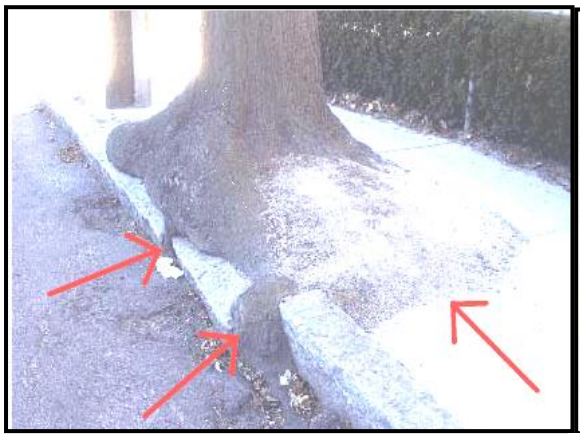
There are many effects of physical weathering. Some of which we have covered in our lessons.

When physical weathering takes place it normally results in the formation of different land forms.

Look at the pictures on the right. Physical weathering contributes to the formation of these landforms.

Different landforms caused by physical weathering

Look at the pictures below they show some different effects of physical weathering.



Trees can physically break curbs and sidewalks as well as natural rocks.

Water in the ground below sealed roads freezes and expands lifting the pavement unevenly and causing sections to collapse and crack after ice melts.

Summary

You have come to the end of lesson 8. In this lesson, you have learnt that:

- the breaking down of rocks at or near the Earth's surface is called weathering.
- physical weathering is the breakdown of rocks due to the direct contact with earth's forces.
- physical weathering is caused by physical changes such as changes in temperature, freezing, the effects of wind, rain, waves, plants and animals.
- there are many effects of physical weathering. Physical weathering contributes to the formation of landforms and can damage roads.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

A. Indicate whether the statement is true or false by writing your answer on the space provided.

_____1. Physical weathering is caused by chemical changes.
_____2. Rocks broken down by sea waves are examples of physical weathering.
_____3. Physical weathering can also have negative effects.
_____4. Temperature can cause physical weathering to occur.
_____5. Wind and water transport broken down materials in physical weathering.

B. Explain the following items.

1. Define physical weathering?

_____
_____
_____
_____

2. Explain how physical weathering can have a negative effect on our surroundings.

_____
_____
_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Lesson 9: Chemical Weathering

Welcome to Lesson 9. In the previous lesson you have learnt that there are two types of weathering. You learnt the first type which is physical weathering so in this lesson you will learn about the second type which is chemical weathering.

Your Aims:

- define chemical weathering
- identify examples of chemical weathering
- state the factors affecting the rates of chemical weathering

Chemical Weathering

Chemical weathering is a slow and ongoing process by which rocks of the Earth's surface is broken down and decomposed by means of some chemical reactions. When rocks are in contact with atmospheric gases, water and living things, chemical reactions take place and the rocks are broken down. New or secondary minerals develop from the original minerals of the rock.

What Causes Chemical Weathering?

1. **Water**

Chemical weathering is most intense in areas that have abundant water. Water can move down cracks in the rock causing weathering to take place.
Pure water contains substances which react with some minerals in the rocks to break them down.

Water causes chemical weathering

Hydrolysis is a chemical reaction caused by water. Water changes the chemical composition and size of minerals in rock, making them less resistant to weathering. Water is the main cause or agent of chemical weathering.

2. **Carbon dioxide**

One of the most well-known weathering processes is **carbonation.** This takes place when rain water combines with carbon dioxide from the atmosphere to form a weak carbonic acid. The weak acid reacts with rocks containing **calcium carbonate** such as limestone and chalk to form calcium bicarbonate. Slowly the weak acid reacts with the calcium carbonate and the limestone is

Chemical weathering of limestone

weathered down. This process speeds up in low temperature because colder water holds more dissolved carbon dioxide gas.

In high air temperature, carbon dioxide gas dissolved in water is less therefore the water is less acidic. Less acid in solution means low reaction therefore, higher temperature means slow reactions. Cold water has more carbon dioxide dissolved in it, therefore the solution is more acidic. More acid means faster reaction so reactions are faster in cold temperature.

3. **Oxygen**

Oxygen is present in air and water and is an important part of many chemical reactions.

Oxidation is the reaction of rock minerals with oxygen, thus changing the mineral composition of the rock. When minerals in rock oxidize, they become less resistant to weathering. Iron, a commonly known mineral, becomes red or rust colour when oxidized. This gives the affected rocks a reddish-brown colour on the surface which weakens the rock and crumbles away easily.

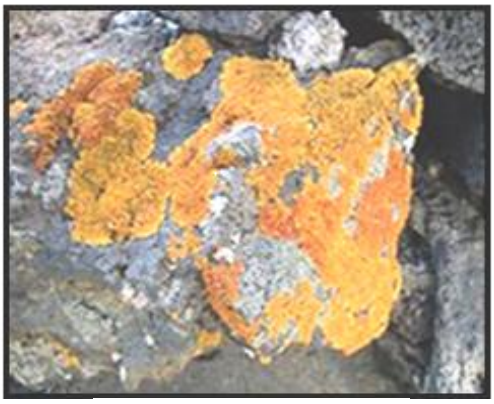
This picture is an example of chemical weathering by oxidation because it shows that when water and oxygen go into a rock, the outcome of the rock will be rusty.

Carbonation involves reaction between acid rain and calcium carbonate in limestone and chalk. Oxidation is the reaction that happens when rocks are in contact with water and oxygen.

4. **Plants and animals**

A number of plants and animals release acidic compounds which creates chemical weathering. This is also called biological weathering. Example, moss on roofs is classified as weathering.

Mineral weathering can be increased by micro-organisms in the soil. Fungi growing on dead trunks and rock produce an enzyme in their roots which speed up weathering. Lichens on rocks are thought to increase the rate of chemical weathering.



Lichens growing on rock

Decaying remains of dead plants in soil may form organic acids which, when dissolved in water, cause chemical weathering.

Weathering is important because it aids in the formation of soil and prepares materials for erosion.

Weathering of Buildings

Buildings made of any stone, brick or concrete are subject to the same weathering agents as any exposed rock surface.

Statues, monuments and ornamental stonework such as the one shown on the picture (right) can be badly damaged by natural weathering processes. These reactions are faster in areas which are severely affected by acid rain.

Weathering of a statue

Chemical reactions take place more quickly at higher temperatures. In tropical countries like Papua New Guinea, chemical weathering is faster than physical weathering. This is because Papua New Guinea has high rainfall, high humidity and fairly high temperature. The particles of rocks produced by weathering slowly form thick deposits.

Erosion

Large amounts of broken-down rock may be removed and transported to another place. The transportation of weathered material is called **erosion**. Erosion is caused by running water, landslides, wind and ice. Erosion will be covered in more details in a later topic.

Summary

You have come to the end of lesson 9. In this lesson you have learnt that:

- chemical weathering involves a chemical change in the rock and results in the breakdown of the rock.
- chemical reactions happen when rocks of the Earth react with water, oxygen and carbon dioxide.
- plants and animals release acidic compounds which creates chemical weathering.
- buildings and other stonework ornaments can be badly damaged by chemical weathering.
- acid is the best agent for chemical weathering.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Answer the following questions on the space provided.

1. What is chemical weathering?

   _____
   _____

2. List four things that cause chemical weathering to happen?

   _____
   _____

3. Carbonic acid reacts with limestone to produce chemical weathering. How is carbonic acid formed?

   _____
   _____

4. What is the name of the process in question (3)?

   _____
   _____

5. Describe how the oxidation reaction in chemical weathering takes place.

   _____
   _____

6. What happens to a rock that is said to be rusting?

   _____
   _____

7. What is produced by plants and animals that cause chemical weathering?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Practice Exercises 5 - 9

Practice Exercise 5

1. D. 2. D. 3. D. 4. C. 5. C.

Practice Exercise 6

Part A.

1. Extrusive igneous rocks /Volcanic rocks
2. Basalt
3. Intrusive igneous rocks /Plutonic rocks
4. Magma
5. Lava

Part B.

1. Igneous rock is formed when magma cools and solidifies either above the earth's crust or beneath it.

2. Intrusive rocks are formed under the earth's crust and cools slowly forming large crystals. Extrusive rocks are formed above the earth's surface therefore it cools very quickly forming very small crystals.

Practice Exercise 7

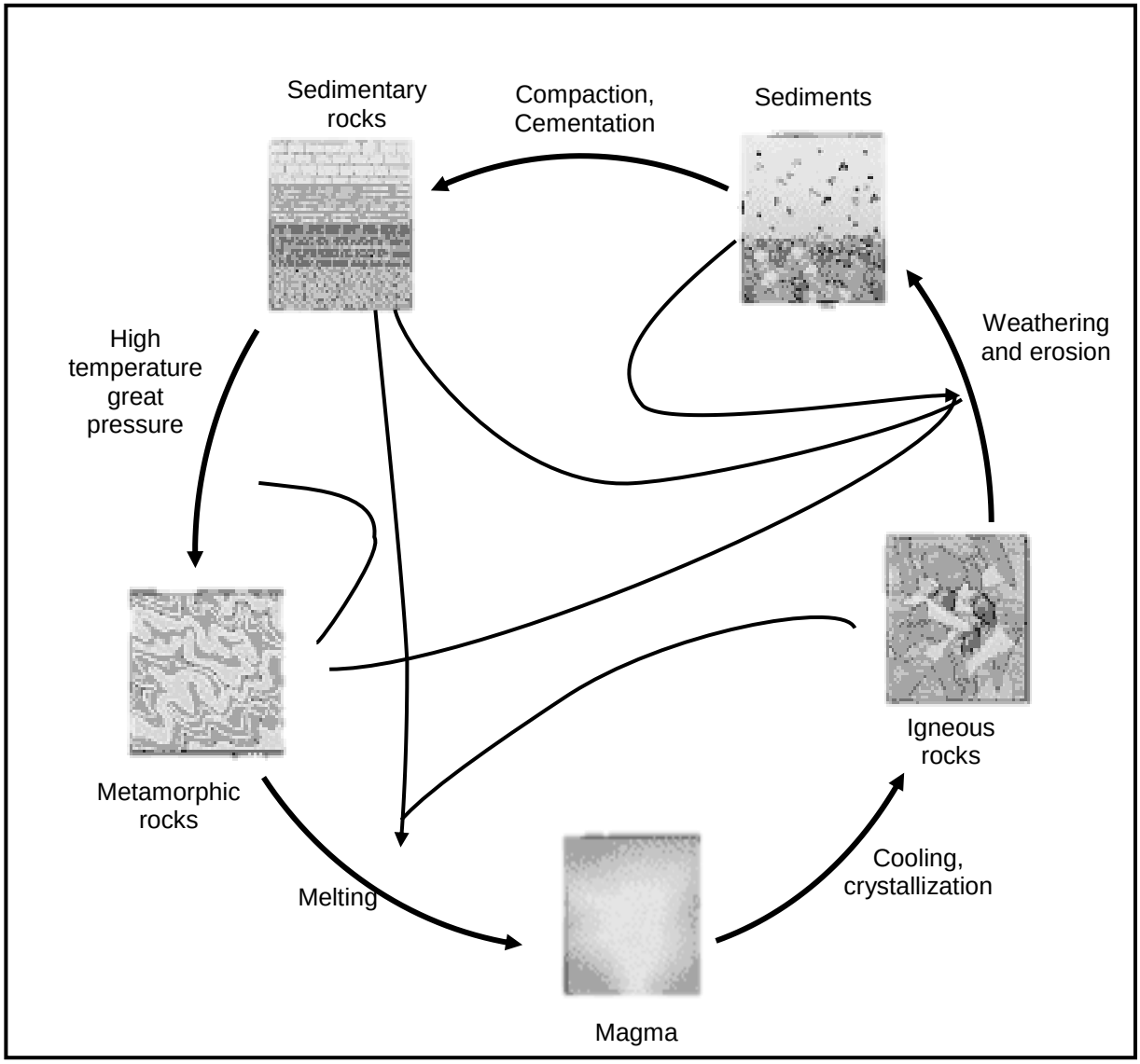
Part A.

1. Metamorphic rocks are igneous or sedimentary rocks that have been transformed by great heat or pressure.

2. When rocks simply get buried by new rocks formed on top of them. The weight on top of rocks forces them deeper into the earth. The heat and pressure cause the rock to change into a new rock. The other method is by the earth's plates.

   The large plates that make up the crust of the earth are always moving. Metamorphic rocks are formed from the pressure and heat caused by the plates crashing into each other. And finally the rocks which the magma come in contact with while passing through the cracks is changed by the heat of the magma and the pressure of the rocks above it.

3.



The rock cycle

Practice Exercise 8

Part A.

False 1.
True 2.
True 3.
True 4.
True 5.

Part B.

1. Physical weathering is the breakdown of rocks due to the direct contact with earth's forces. It is caused by physical changes such as changes in

temperature, freezing, the effects of wind, rain and waves and plants and animals.

2. Physical weathering can damage roads and structures made to help us.

Practice Exercise 9

1. Chemical weathering is the process by which rocks of the Earth's surface are being broken down by means of chemical reactions.

2. Oxygen, water, carbon dioxide, plants and animals

3. Carbonic acid is formed when rain water combines with carbon dioxide gas from the atmosphere.

4. Carbonation

5. Oxidation occurs when rocks combine with oxygen and water to form hydroxides and oxides.

6. Oxidation gives a reddish-brown colour to the rock, it weakens the rock and grumbles away easily.

7. Plants and animals release acidic compounds that cause chemical weathering.

REVISE TOPIC 2 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 2: Rock Cycle and Weathering

Now, revise all lessons in this Topic and then do **ASSIGNMENT 6.** Here are the main points to help you revise.

Lesson 5: Sedimentary Rocks

- Sedimentary rocks are formed from layers of sediment deposited by seas, rivers, wind, or glaciers.
- Most sediments are fragments of eroded rock.
- The layers of rock in sedimentary are called strata/sedimentary beds.
- Broken-down rock produces sediment which may become a sedimentary rock.
- Sedimentary rocks usually have layers and often contain fossils.
- Sedimentary rocks are classified by their origin, composition, grain size and shape.
- Sedimentary rocks have different kinds of cementing material.

Lesson 6: Igneous Rocks

- Igneous rock is formed when magma cools and solidifies either above the earth's crust or beneath it.
- There are two main types of igneous rocks; intrusive and extrusive rocks.
- Intrusive igneous rocks are formed under the earth's crust and cools slowly forming large crystals. Granite rock is an example of an intrusive rock.
- Extrusive igneous rocks are formed above the earth's surface therefore it cools very quickly forming very tiny crystals. Basalt rock is an example of extrusive rocks.
- Composition is another way to classify igneous rocks. The composition of the rocks is determined by the minerals that make up the magma from which they form.
- Felsic rocks are light-colour rocks that contain a lot of feldspar and quartz.
- Mafic rocks are dark-colour rocks that contain a lot of magnesium and iron.
- Intermediate rocks are appropriately named because they are rocks that are between light- and dark-colour and share minerals with both felsic and mafic rocks.
- There are also ultramafic rocks, which are rocks that contain mainly magnesium and iron and very little silica. Because they have mostly mafic minerals they are like super-charged mafic rocks - in other words, ultramafic

Lesson 7: Metamorphic Rocks

- Metamorphic rocks are igneous or sedimentary rocks that have been transformed by great heat or pressure.
- This heat and pressure cooks the rocks, changing their structure.
- Rocks can be changed to metamorphic rocks when: they are buried by new rocks or formed from the pressure and heat caused by the earth's plates crashing into each other. Or when magma passes through cracks in rocks.
- Marble, Schist, slate and gneiss are examples of metamorphic rocks.
- The rocks are recycled over millions of years. This is called the rock cycle.

Lesson 8: Physical Weathering

- The breaking down of rocks at or near the Earth's surface is called weathering.
- Physical weathering is the breakdown of rocks due to the direct contact with earth's forces.
- Physical weathering is caused by physical changes such as changes in temperature, freezing, the effects of wind, rain, waves, plants and animals.
- There are many effects of physical weathering. Physical weathering contributes to the formation of landforms and can damage roads.

Lesson 9: Chemical Weathering

- Chemical weathering involves a chemical change in the rock and results in the breakdown of the rock.
- Chemical reactions happens when the rocks of the Earth reacts with water, oxygen and carbon dioxide to form hydroxides and oxides.
- Plants and animals release acidic compounds which creates chemical weathering.
- Buildings and other stonework ornaments can be badly damaged by chemical weathering.
- Acid is the best agent for chemical weathering.

NOW DO TOPIC TEST 2 IN YOUR ASSIGNMENT 6.

TOPIC 3

STRUCTURE OF THE ATMOSPHERE

In this topic you will learn about:

- **layers of the atmosphere**
- **the properties of air**
- **atmospheric pressure**
- **the moving air**

INTRODUCTION TO TOPIC 3: STRUCTURE OF THE ATMOSPHERE

Hold your hand in front of your face, and breathe in deeply. Now gently blow outward towards your fingers. What do you feel? Does it feel cool and tingly? What you felt blowing past the tips of your fingers is commonly referred to as air.

Kassie blowing air on her palm

Air is one of the primary things that make life on Earth possible. But what is air, and do all planets have it? Air is important to both plants and animals The Earth's surface is surrounded by a layer of gases known as the atmosphere, which extends upward from the surface, slowly thinning out into space.

The Earth's atmosphere is made up of a mixture of variety of gases and other particles and **aerosols*** collectively known as air which covers the earth. The atmosphere provides various functions, to sustain life. It protects us by filtering out deadly **cosmic rays***, powerful **ultraviolet (UV) radiation*** from the Sun, and even shooting stars on contact course with Earth. One well-known layer is the ozone layer protecting life below from the harmful effects of ultraviolet (UV) radiation from the Sun.

In this Topic we will discuss further the different layers of the atmosphere, the properties of moving air and how atmospheric pressure is measured.
You should be able to ask yourself the following questions as you study Topic 3.

- What are the layers of the atmosphere?
- What are the properties of air?
- How do man's activities affect the atmosphere?
- How planes and birds fly?
- What is an atmospheric pressure?

In this Topic, you will find the answers to these questions and all other questions relating to structure of the atmosphere.

Lesson 10: Layers of the Atmosphere

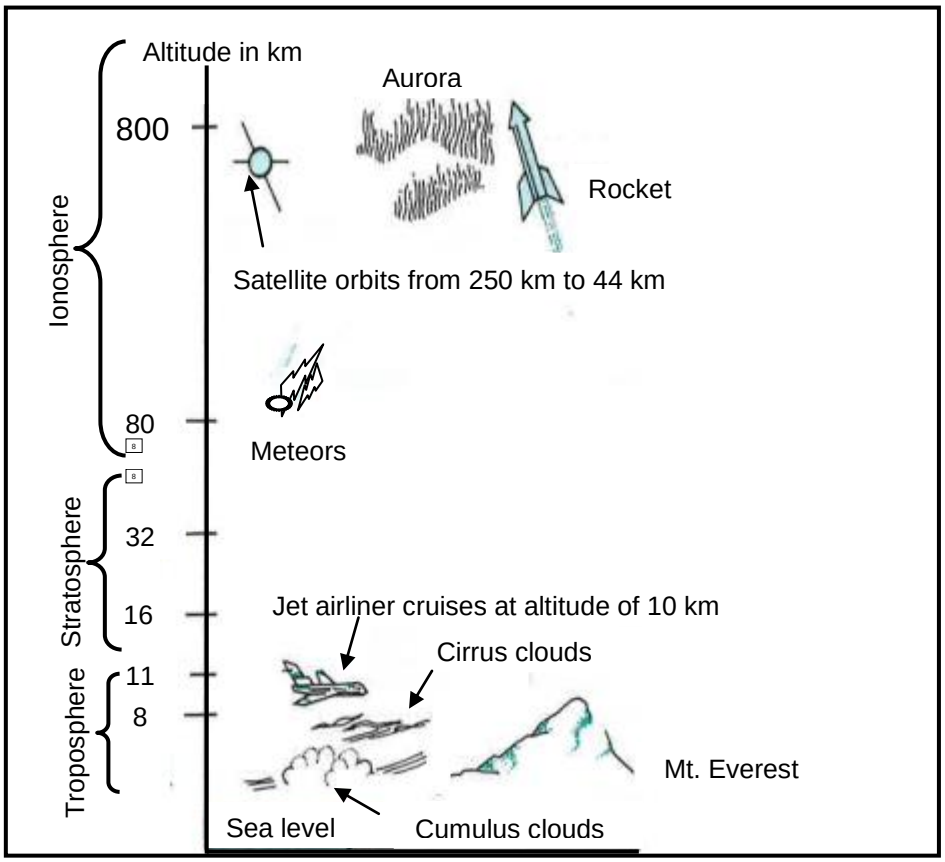
Welcome to Lesson 10. We are surrounded by a layer of gases that is very important to us. Without these gases there would not be any life on Earth. In this lesson we are going to look at the importance of gases found in the air and the importance of each gas types.

Your Aims:

- define atmosphere and ozone layer
- describe the three zones of the atmosphere
- identify the component of air and their importance
- discuss how man's activities affects the atmosphere

The Atmosphere

We live at the bottom of an invisible ocean called the **atmosphere**, a layer of gases surrounding our planet. It is a blanket of gases and suspended liquids and solids that entirely envelops the earth. It is almost 400 km thick. Water vapour and dust are also part of Earth's atmosphere. These gaseous cover of the earth is held around it by gravitational attraction. Other planets and moons have different atmospheres, while some others have no atmospheres at all. The air, sun and weather are the three main causes of change in the weather. Air has weight and presses down on everything. At sea level this pressure is greater, but becomes less with increasing height. The density of the atmosphere decreases rapidly with altitude.



Layers of the Atmosphere

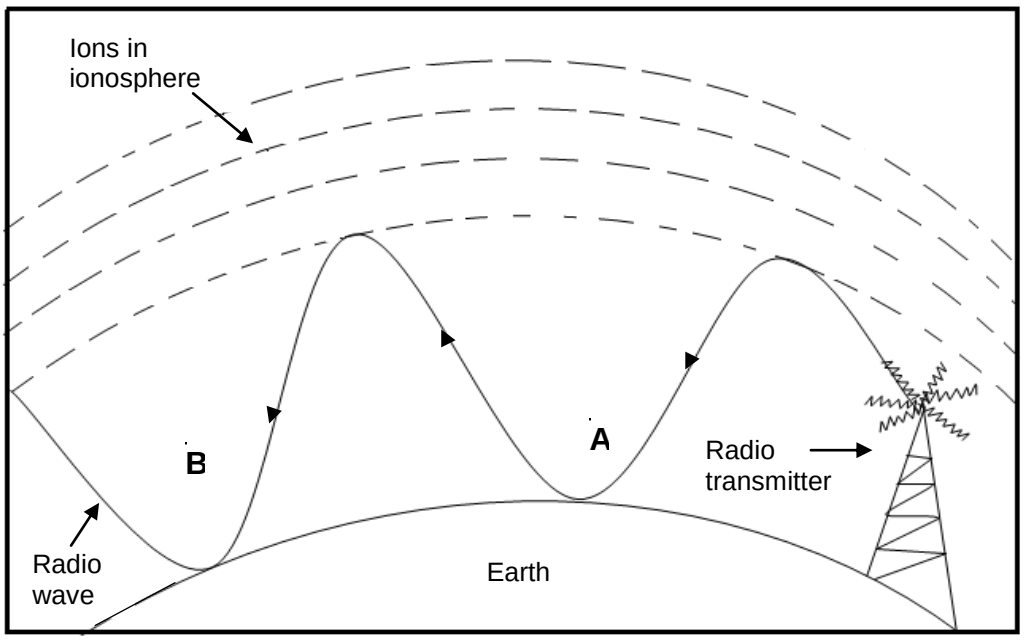
Layers of the Atmosphere

1. **Troposphere** (0 to 12 km).
   The lowest layer of the atmosphere. It is about 11 km thick above Papua New Guinea. It contains 75% of the gases in the atmosphere. Air is closest to the earth, where we live, airplanes fly at the top of it. It contains most of the water vapour, dust and clouds, and is the main influence on our weather. Change of weather takes place throughout the year. The top of the troposphere is higher in summer than in winter. The temperature drops about 6.5 degrees Celsius for every kilometre above the earth's surface. The height of this layer at equator is 16 km and at poles 7 km.

2. **Stratosphere** (12 to 50 km)
   The temperature remains fairly constant (-60^{o}C.). It acts as a shield for the earth's surface and contains the ozone layer which absorbs ultraviolet radiation from the Stratosphere. As altitude increases, temperature also increases. Strong horizontal winds blow, but there is little turbulence. Ideal for planes to fly.

3. **Ionosphere** (80 km and up)
   A layer of free electrons and ions—reflects radio waves. It extends from about 80 to 550 km. Gas particles absorb ultraviolet and X-ray radiation from the sun.

The particles of gas become electrically charged (ions). Radio waves are bounced off the ions and reflect waves back to earth. This generally helps radio communication. However, solar flares can increase the number of ions and can interfere with the transmission of some radio waves. The ionosphere is named for ions created by energetic particles from sunlight and outer space. Ions are atoms in which the number of electrons does not equal the number of protons, giving the atom a positive (fewer electrons than protons) or negative (more electrons than protons) charge.



Radio waves are reflected from the ionosphere making long-distance radio communication possible.

The Ozone Layer

A layer in the earth's stratosphere at an altitude of about 10 km containing a high concentration of ozone, which absorbs most of the ultraviolet radiation reaching the earth from the sun. This is important to life on Earth because it absorbs biologically harmful ultraviolet radiation from the Sun. The ozone layer is lower atmosphere compared to the main components of the atmosphere. It is mainly located in the lower portion of the stratosphere from about 15–35 km though the thickness varies seasonally and geographically. About ninety percent (90%) of the ozone in our atmosphere is contained in the stratosphere.

What is the ozone layer made of?
The ozone layer is made of three oxygen atoms, produced by the sun to protect the earth from the dangerous effects of ultraviolet rays.Ozone is only a trace gas in the atmosphere—only about 3 molecules for every 10 million molecules of air. But it does a very important job. Like a sponge, the ozone layer absorbs bits of radiation hitting Earth from the sun. Even though we need sun's radiation to live, some of it can damage living things. The ozone layer acts as a shield for life on Earth because it traps those harmful rays.

The ozone layer is getting thinner. Chemicals called **chlorofluorocarbons** (CFCs) are making the ozone layer thinner. A chlorofluorocarbon (CFC) is a molecule that contains the elements carbon, chlorine, and fluorine. CFCs are everywhere, mostly in refrigerants and plastic products. Businesses and consumers use them because they are cheap, they do not catch fire easily, and do not poison living things. But the CFCs eat away the ozone layer once they get blown into the stratosphere.

Activity 1.1: Now test yourself by doing this activity.

Use the following words to answer what is being asked. They may be used more than once. Write your answers on the space provided.

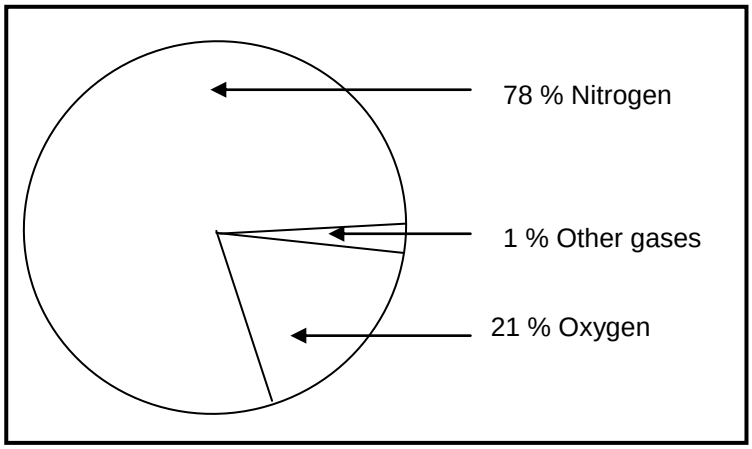
Troposphere Stratosphere Ionosphere

1. Contains 75% of the gases in the atmosphere. _____
2. A layer of free electrons and ions . _____
3. It contains the ozone layer. _____
4. Gas particles absorb ultraviolet and X-ray radiation from the sun. _____
5. It extends from about 80 to 550 km. _____
6. It is about 11 km thick above Papua New Guinea. _____
7. Ideal for planes that can fly in this part of the atmosphere. _____
8. The temperature remains fairly constant (-60^{o}C). _____
9. The lowest layer of the atmosphere. _____
10. Air masses, areas of high and low pressure systems are in this layer. _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 10.

The Components of the Atmosphere

Air is a mixture of gases. The three most important gases are oxygen, nitrogen and carbon dioxide. Water vapour and other gases are called noble gases, also found in the atmosphere. Noble gases do not readily react with other substances to form compounds. Argon, neon and helium are examples of noble gases.



Composition of gases in the atmosphere

1. Nitrogen – 78%

The main use of nitrogen is in the manufacture of fertilizers. Living things need it to make proteins. Nitrogen cannot be used directly from the air. The Nitrogen Cycle is nature's way of supplying the needed nitrogen for living things.

Why is nitrogen the most common element in the earth's atmosphere?

The answer lies mostly in three facts:

1. Nitrogen is **volatile*** in most of its forms.
2. It is unreactive with materials that make up the solid earth.
3. It is very stable in the presence of solar radiation.

2. Oxygen – 21%

Oxygen is very important and is used by all living things. It is essential for respiration and necessary for combustion or burning of any material requiring oxygen. Oxygen (O_2) is very important element to sustain life. Without proper Oxygen, our health begins to suffer and/or we die.

3. Carbon dioxide

Carbon dioxide is absorbed by plants. Plants use it to make oxygen. Scientists are afraid that the burning of fossil fuels such as coal and oil are adding more carbon dioxide to the atmosphere. This gas is important in maintaining the Earth's surface temperature. Carbon dioxide (and smaller amounts of other greenhouse gases, such as methane) form a kind of "greenhouse glass" barrier.

4. Water vapour

Essential for life processes and also prevents heat loss from the earth. Water vapour plays a dominant role in the **radiative balance*** and the **hydrological cycle***. In the lower atmosphere, the water vapour concentrations can vary by orders of **magnitude*** from place to place. Water vapour in the air is sometimes visible as clouds. Water enters the atmosphere through the water cycle bringing molecules in the air into the oceans, lakes, and rivers.

5. Noble Gases (Group of Non-reactive Gases)

Argon, neon, krypton, xenon and helium are all chemically in-active. Argon is most used gas. Its main uses are in metal works. Because argon is very unreactive, it prevents chemical reactions of the very hot metal being welded. The most familiar use neon gas is in “neon” signs. These are lamps constructed usually from clear, colourless glass tubes filled with a gas which emits light when an electric current passes through it.

Impact of Man's Activities

Carbon dioxide gases increase the temperature of the earth. These gases are created by man destroying our environment or sending bad gases to the atmosphere. The reduction in the forest cover also contributes to Global warming results. This in-turn results in the increase of ice melting and rise of sea water level.

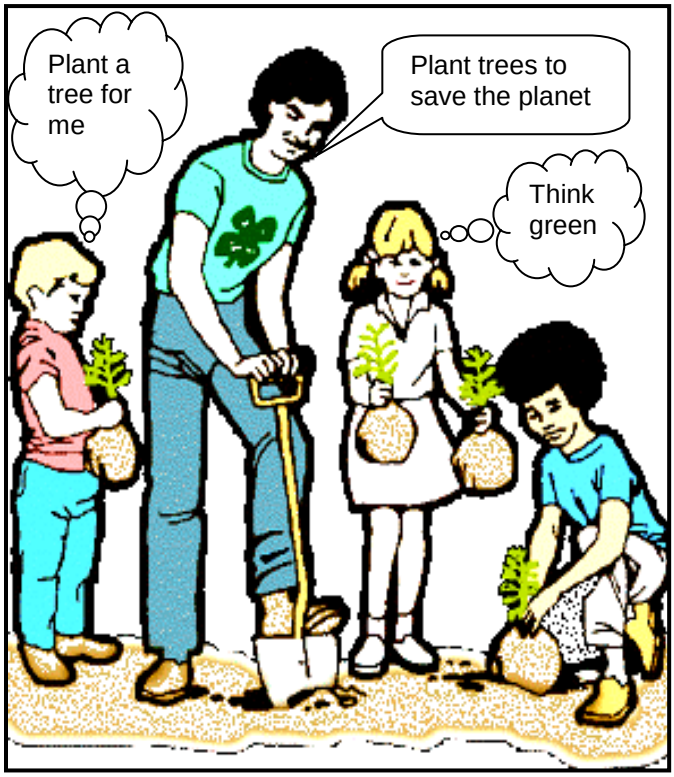
Man’s activities that cause changes to atmosphere

Ways to protect the environment

Global warming and its consequences are rather alarming. Below is a list of simple things you can do to actually contribute to save the environment.

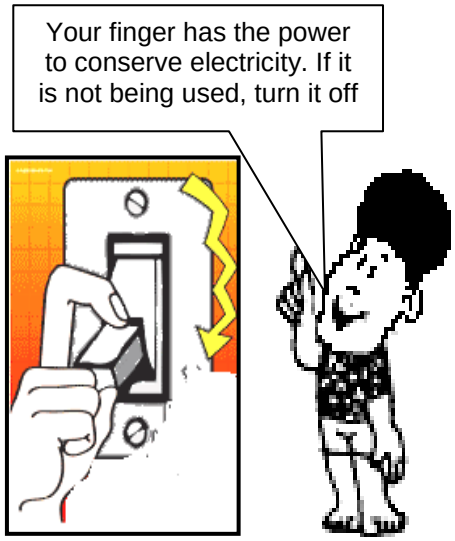
1. **Plant trees or save trees. Think green**.

Saving trees help save wildlife. The destruction of trees is the cause of global warming. So if you can just plant as many trees as you can and ENSURE that they survive; you are doing the right thing. If you cannot plant trees, just make sure you can save trees from being cut down, or drying up and dying due to lack of water. Make it a point to water at least one tree or plant one in a day, in your yard, garden or neighbourhood.



2. **Save paper:** avoid taking unnecessary print outs. Use recycled paper.

3. **Stop using deodorant and aerosol sprays.**
Air conditioners, refrigerators aerosol sprays use CFC or chlorofluorocarbons. When CFC leaks into the atmosphere, it does deplete the ozone in the air. The ozone layer is what protects us for harmful radiations of the sun.



4. **Limit the use of air-conditioners**- build up your tolerance levels and get used to living in natural weather and climatic conditions.

5. **Conserve electricity**.
Switch off the lights, fans, air-conditioners/heaters when leaving a room if you are the last one to leave. Switch off any appliances when you are not using them or taking a break in the middle of an activity.

Set your heaters and coolers to the optimum temperature. The sun gives off its energy for free, make full use of it; use solar energy where possible. Watch less TV.

6. **Save water where possible** - for example, turn off the faucet while you brush your teeth, turn on the tap only when you are ready to rinse or gargle.

In the shower, turn off the shower while you soap / shampoo yourself turn it on only when you are ready to stand under the water spray. Using a bucket and mug to take a bath instead of the shower will also reduce the amount of water you need. When washing your car, first dust off the dry dust. Wash your cars using a bucket and mop. You need less water that way.

7. **Drive less, walk more** - whether to school, office or on a date. Go for romantic walks instead of drives with your date. Walking is good for the heart, in more ways than one. Use a bicycle. All of this will not only help save the environment, but will also help you stay fit and in shape.

8. **Car pool if you have to drive**.
Carpooling (you can call it as car-sharing, ride- sharing, lift-sharing) basically it is a share to ride (car, bike and van) for individuals sharing commute expenses.

Using fewer cars means less pollution, conservation of habitat, and less demand for new roads and parking lots. Using fewer cars also means less production of greenhouse gases, a major contributor to climate change. Carpool regularly and you can feel proud that you are helping the environment.

9. **Use less plastic. Use bio-degradable stuff**.
Take your own shopping basket/bag along when you go shopping. There was an era when plastic carry-bags did not exist. The earth was a much healthier place then. These days plastic carry bags are used freely and they mess up the environment as most of them are not bio-degradable

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Activity 1.2: Now test yourself by doing this activity.

Name the main gases of the atmosphere beside the descriptions below.

_____ 1. Group of non-reactive gases
_____ 2. Used by all living things
_____ 3. Manufacture of fertilizers
_____ 4. Plants use to make oxygen
_____ 5. Plays a dominant role in the radioactive balance and the hydrological cycle

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 10.

Summary

You have come to the end of lesson 10. In this lesson you have learnt that:

- earth is believed to have formed about 5 billion years ago.
- we live at the bottom of an invisible ocean called atmosphere, a layer of gases surrounding our planet.
- there are three layers of the atmosphere:
  i) troposphere – where we live.
  ii) stratosphere – contains the ozone layer and ideal for planes to fly
  iii) ionosphere – a layer of free electrons and ions (reflects radiowaves).
- the ozone layer is important to life on earth because it absorbs biologically harmful rays like ultraviolet radiation from the Sun.
- three most important gases in the atmosphere are oxygen, nitrogen and carbon dioxide.
- the activities of people are polluting the atmosphere, which in turn

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NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE.

Practice Exercise 10

Answer the following questions.

1. Name the 3 layers of the atmosphere.

   i) _____
   ii) _____
   iii) _____

2. Name the 3 most important gases which make up the air.

   i) _____
   ii) _____
   iii) _____

3. What do you call the region within the stratosphere where this thin shell of ozone is found?

   _____

4. What is the ozone made of?

   _____

5. Give and explain two ways on how to protect the environment.

   i) _____
   ii) _____

6. Describe atmosphere

   _____
   _____

7 In the troposphere layer, what happen to the altitude and temperature if the air is thin?

   _____
   _____
   _____

9. What causes the holes in the ozone layer?

_____

_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activities

Activity 1.1

1. Troposphere
2. Ionosphere
3. Stratosphere
4. Ionosphere
5. Ionosphere
6. Troposphere
7. Stratosphere
8. Stratosphere
9. Troposphere
10. Troposphere

Activity 1.2

A. Noble gases
B. Oxygen
C. Nitrogen
D. Carbon dioxide
E. Water vapour

Lesson 11: The Properties of Air

Welcome to Lesson 11. Air is essential for life on Earth. Without air to breathe, we could not survive, but what exactly is air? Air is all around us. We cannot investigate because we cannot see, taste, or touch it. With this lesson, the students will become familiar with some properties of air by participating in simple hands-on experiments.

Your Aim:

- discuss the properties of air

What is Air?

Air is matter made up **of molecules*** and **atoms***. It interacts with objects because we can see trees swaying in the breeze. We also know it moves things because the clouds move in the sky and storms approaching us from the distance. We know that the air moves because it brings us our weather. Air can change temperature - we can feel this cold or hot air against our skin. Sometimes the air can smell. It is able to carry the smell of flowers to our noses. Hot air rises and can hold moisture. We see birds using the air to travel from place to place and we also see dried leaves being blown around by the wind. Air can become dirty from dust and pollution. We know that air also take up space in tins, boxes, blown balloons or in tyres.

Air is matter because it takes up space and has mass. Air is all around us. Two objects cannot occupy the same space at the same time as shown in the diagram.

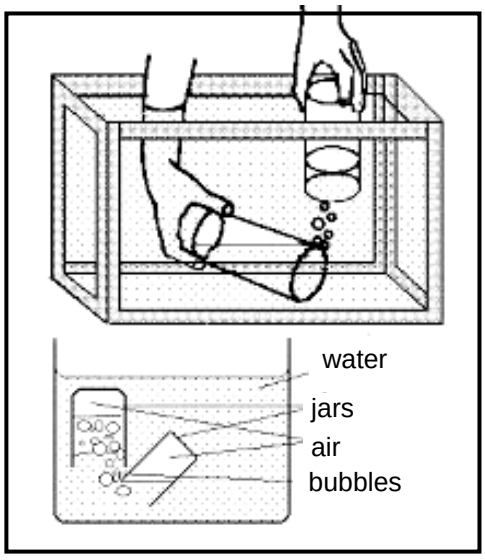
Properties of Air

Has mass

The simplest way to show this is simply to move your hand quickly through the air. Wave it in a wide, fast arc in front of you or stick your hand out the window of a moving car. You can feel the air against your hand.

We have all felt air push against our bodies on a windy day. Without mass, there would be no "push.

To show that air is matter, we need to prove air has mass and takes up space. It's easier to prove that air takes up space, so let us do a balloon experiment.



Air takes up space
Transfer air under water

Activity 1.1: Now test yourself by doing this activity.

Balloon experiment

Aim: To prove that air has mass and takes up space.

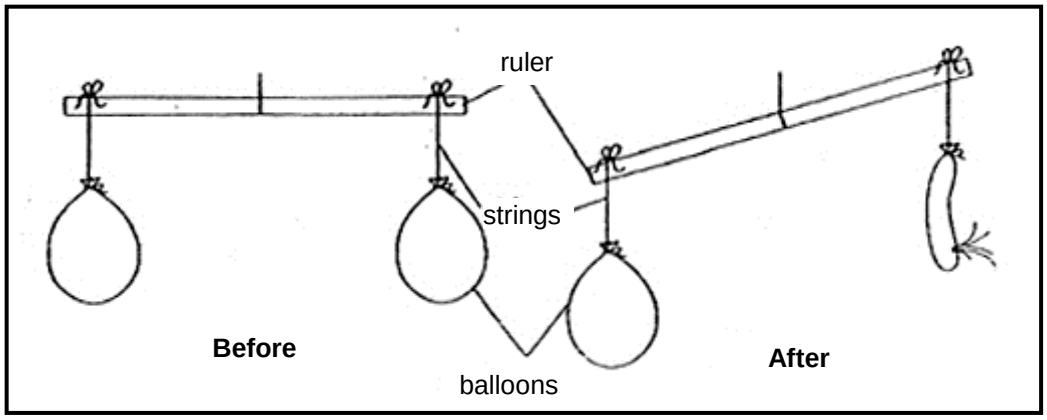
What you will need:
A meter long stick, sticky tape, string, piece of needle or sharp pointed object and two balloons.

Step 1: Take one string and tie one end of the string in the middle of the meter long stick. Take the other end of the string and tape it to the top of a table or a counter, just make certain that the meter long stick is free to move around.

Step 2: Blow the balloons. The balloons get larger as you blow them. The only way that air can make them larger is when air takes up space, so half of our proof is complete. Tie the balloon around the neck so that they stay inflated, we will need both balloons for the second half of this problem. Tie a section of string around the neck of each balloon. On one balloon, make an "X" with two pieces of sticky tape (if you want to be fair, you can make a tape "X" on the second balloon as well, but we really only need one).

Step 3: Take the balloons and tie each one to the metre long stick, one on each end of the metre long stick. Balance the metre long stick by repositioning the balloons, if necessary.

You should have two balloons hanging from a metre long stick, one from each end. If one of the balloons changes mass, we will be able to tell because the metre long stick will 'tilt' towards the more massive object. So, all you need to do is to let the air out of one of the balloons. Take the needle or sharp pointed object and CAREFULLY poke a hole in the centre of the balloon with "X". You do not want to pop the balloon - you just want to make a hole so that the air will leak out. Hopefully, the tape will keep the balloon together.



Balloon experiment showing that air has mass

What happened? Write your observations

_____
_____
_____
_____
_____

With this experiment you have shown that air takes up space and has mass, so you have proven that air is matter.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 11.

Showing pressure
Compressed air has great strength. The book blast experiment is a science project that demonstrates just how powerful it can be.

Activity 1.1 **Now test yourself by doing this activity.**

Book Blast Experiment

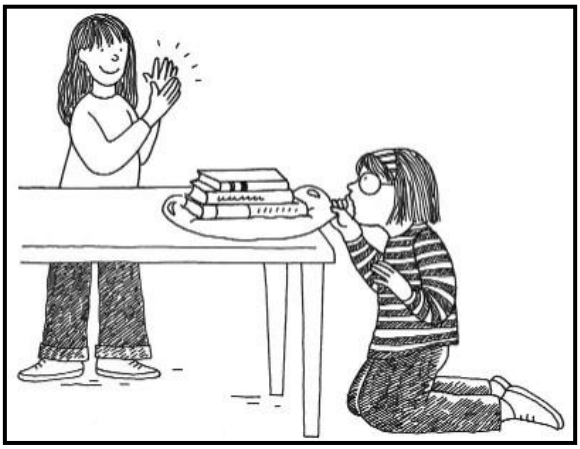
Aim: To demonstrate just how powerful air can be.

What you will need:
Large airtight plastic bag, 3 books

Step 1: Ask a friend to move 3 books stacked on top of one another on a table by simply blowing at them. Of course, your friend will not be able to do it!

Step 2: Place a large plastic bag on the table, and put the 3 books on top of the bag. Leave the open end of the bag sticking out over the edge of the table.

Step 3: Hold the opening together, leaving a hole as small as possible. Blow into the bag. Take your time; stop to rest if you need to.



Blow up your books with a book blast experiment.

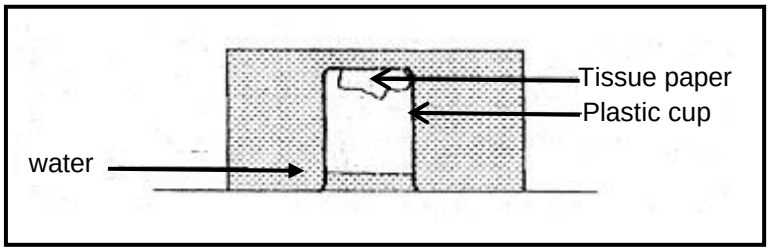
What happened? Write your observations

_____
_____
_____

Air occupies space

For this property, you will need some plastic cups (clear ones are best), a container to hold water, and some tissue paper.

Take a paper towel and wad it up so that it will stick inside a cup even if you hold the cup upside down. Fill a bowl with water; slowly lower the cup into the water.

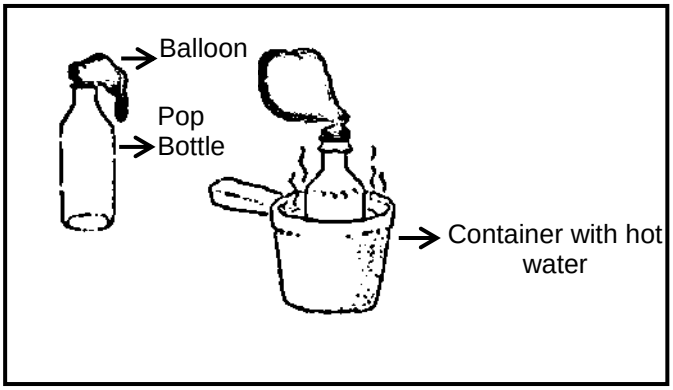


In this step, it is critical that you lower the cup straight down and not on an angle. Make sure the cup is fully submerged, and then slowly raise the cup out of the water, again being sure that you raise it straight up. The air bubbles prove that there is air that has volume within the cup.

Air holds heat

To show if this is true.

You will need hot water, a coke bottle .Air has temperature, like most things around us, and air expands when it gets hot and contracts when it gets cold. Temperature has effect on volume, and that volume has effect on pressure.



Presence of water vapour in air

Take a glass vessel which is absolutely dry on the outside. Put some ice cubes in it. Within a short time you will observe that tiny droplets of a colourless liquid get condensed on the outside surface.

This occurs because the air layer touching the outer surface of the vessel becomes very cold and condenses the water vapour in it to droplets. Ordinary air seems to be dry. It does not cause wetness on our body or clothes. Actually, air can hold more water vapour.

The energy of air

Air has energy that's why moving air can be used to make other objects. An example is the windmill in which energy can be used to pump water or to drive sailing boats.

The elastic nature of air

An elastic substance is one that returns to its original shape and size when forces that are pushing or pulling on it are removed. Rubber bands and coil springs are the common examples of elastic materials. A bicycle pump is an example of the elasticity of air.

Pneumatic is a device use in the elastic property of air. Other examples of the use of air are air-filled balls, such as volleyballs, soccer balls, air mattresses and foam rubber cushions.

Summary

You have come to the end of lesson 11. In this lesson you have learnt that:

- air is matter because it takes up space and has mass and so must be made up of molecules and atoms.
- air can change temperature, we can feel the temperature of the air against our skin.
- there are properties of air, showing pressure, has weight or mass, volume, temperature, velocity, energy, elasticity and presence of water vapour .

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE.

Practice Exercise 11

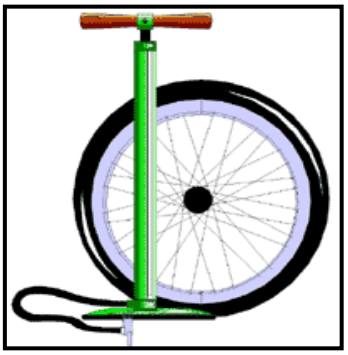
A. Complete the sentences by filling the correct word below.

molecules temperature matter atoms weather

Air is (1) _____so it must be made up of (2) _____ and (3) _____. We know that the air must move because it brings us our (4) _____. Air can change (5) _____, we can feel the temperature of the air against our skin.

B. Choose the best answer.

1. Air pumps are often used to pump up bicycle and vehicle tires. As Daphne pumped air into her bicycle tyre she explained to her friend Daniel the reason why the tire gets firm when squeezed.



Which of the following explanations correctly explains why tyres get firm?

‘ A. Air expands to fill the space it is in.

B. The faster air moves, the less pressure it exerts.

C. Air turns into a solid when it is squeezed into a small space.

D. Air is loosely packed and can be compressed into smaller spaces, resulting in a higher pressure.

2. Air pumps are often used to pump up bicycle and vehicle tyres. Why are bicycle and vehicle tyres not blown up with the air from your mouth?

A. Your mouth can not compress air

B. The air from your mouth is too warm.

C. The air from your mouth is not the right mix of gases.

D. There is not enough force from your mouth to create the right amount of air pressure.

3. Stephanie recalls that air expands when heated and contracts when cooled. She decides to fill up four balloons and place them in different temperatures to

test these properties of air. When testing for expansion and contraction, the two variables Stephanie would have to keep constant are the

A. type of material the balloons were made of and their colour.

B. the colour of the balloons and the time kept in the different locations

C. the amount of light each balloon receives and the colour of the balloons.

D. type of material the balloons were made of and the amount of air in each balloon

---

4. Clifford placed a sponge in the bottom of a glass and then turned it upside down and submerged it in a sink full of water. A property of air which explains why the sponge did not get wet is that

A. air takes up space.

B. air contains oxygen.

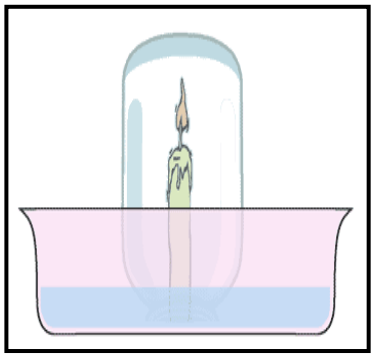
C. air expands when heated.

D. air contracts when cooled.

---

5. Hayley designed an air experiment she could perform at home to impress her family. She followed these procedures:

Secure a candle in the middle of a glass baking dish with a few drops of wax.
Add enough water to the pan so the height of the water is 2 cm.



Add 2 drops of food colouring for added visual effect. Light the candle.

Carefully place a large jar upside down over the candle so that the top of the candle is not submerged in the water. Observe what happens.
Hayley shows the results of her experiment.

If Hayley was to repeat her experiment to include a smaller jar and a larger jar, which variable would be the manipulated or changing variable in this experiment? The

A. amount of air in the jars.

B. amount of water in the pan.

C. time taken for the flame to be extinguished.

D. amount of water pulled into the jar when the flame is extinguished.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activities

Activity 1.1

Observations
If all went well, the balloon with the “X” mark has lost its shape when the air leaked out. The end of the meter stick with the deflated balloon should have risen into the air. It did this because there was less mass in the balloon after it deflated. The only way the balloon could have lost mass is if the air in the balloon escaped.

Activity 1.2

Observations
If you blow long and hard enough, the books will rise off the table. They will be supported by the compressed air in the plastic bag.

Lesson 12: Atmospheric Pressure

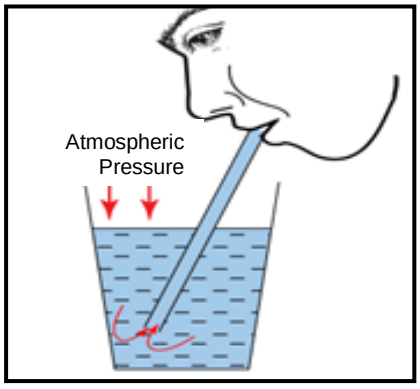
Welcome to Lesson 12. In this lesson, we will learn about the application of air pressure in our daily life.

Your Aims:

- define atmospheric pressure
- explain areas of high and low pressure
- describe air pressure and the instruments used to measure air pressure
- discuss factors that affects air pressure

Atmosphere Pressure

Atmospheric pressure also known as air pressure is the force caused by air pressing down onto the surface of the earth.

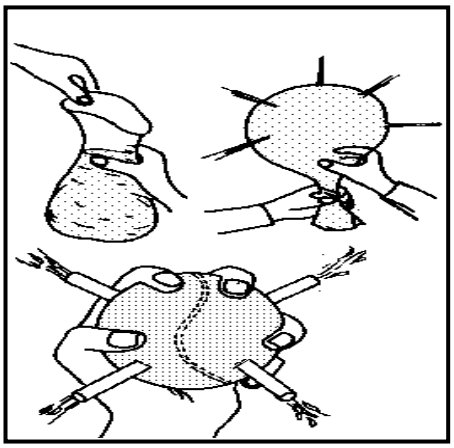


Drinking straws are used everyday to drink fluids which are stored in containers like cans. A suck and drink process is easy, but this simple process comprised the use of atmospheric pressure. This is also known as air pressure that has powerful force caused by a layer of air called the atmosphere.

For example when one is sucking fluid with the use of straw, it creates a region of low pressure inside the straw due to the pressure that has been "absorbed" to the mouth. When the pressure of our surrounding (atmospheric pressure) is higher than the pressure inside the straw, it pushes the fluid towards the inside of the straw, by this, the fluid will reach the mouth of the person. On the other hand if you try to blow the straw, the pressure inside the straw will increase. When the inside pressure is higher than our surrounding pressure (atmospheric pressure) the air inside the straw will be forced out.

We do not feel the pressure of the atmosphere because of the following reasons:

i) our bodies are built to withstand normal air pressure and from within
ii) air pressure acts equally in all directions
iii) changes from one place to another and
iv) decreases the higher you go above ground level. This feature exists because at high place, the amount on air decreases. This explains why the air pressure on the top of a mountain is lower that at the foot of the mountain.



Air pressure acts equally in all directions

Areas of high and low pressure

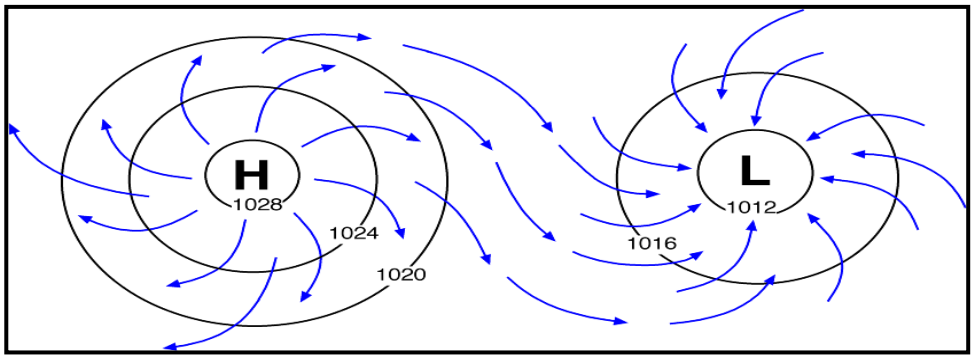
Air pressure varies with altitudes (height above sea-level) and temperature. The air pressure at sea-level has higher temperature at higher altitude where the temperature is low. As you move away from the sea-level, the amount of air pressing on the Earth's surface will gradually decrease and become thinner.

Comparison of air pressure between sea level and high altitude areas

Air pressure at the sea-level
- more dense
- high pressure
- thick air
- more weight

Air pressure at high altitude areas
- less dense
- low pressure
- thin air
- less weight

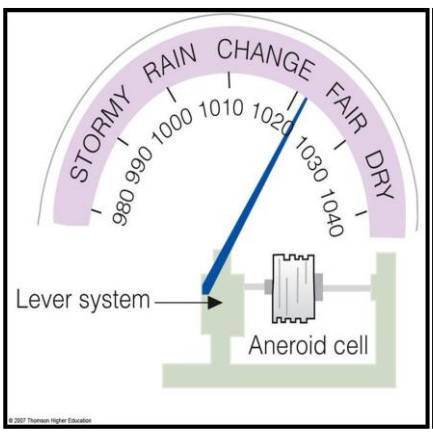
When you are travelling up the Highlands from Lae, you will realize that the atmospheric pressure will slowly decrease and become thinner. Because air pressure varies with height, pilots use barometers to measure how high they are flying above the ground. Air pressure changes constantly from place to place from hour to hour. Because of the changes every weather stations keep a close watch on air pressure. Air pressure readings are taken every hour. Some weather systems have slightly higher pressure than others. You might have heard of high pressure and low pressure weather systems.



High pressure and Low pressure weather systems.

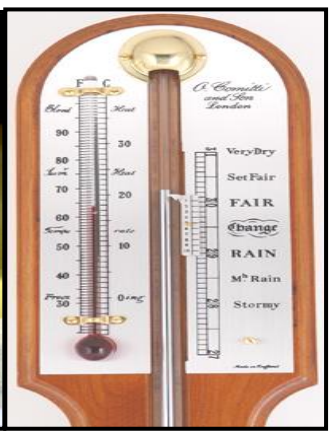
Measuring Atmospheric Pressure

Even though we cannot see air, it is real and has pressure that changes the atmosphere. It is higher at sea level, and lessens as you go higher up in the atmosphere.



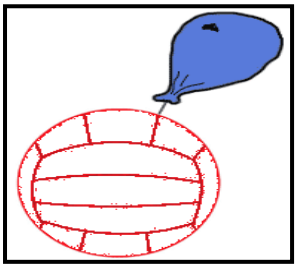
Aneroid barometer

Barograph



Mercurial barometer

Barometer is a device used to measure atmospheric pressure in unit of millibar (mb) where 1 millibar of atmospheric pressure represents approximately 10 metres of height above the ground. Because atmospheric pressure changes with distance above or below sea level, a barometer can also be used to measure altitude. There are two main types of barometers: **mercury** and **aneroid**.



A non- liquid barometer called the **aneroid barometer** can be used in place of a mercury barometer. It is widely used in portable instruments because of its smaller size and convenience. It is easier to move and often easier to read. This instrument contains sealed waters that shrink or spread out depending on changes of atmospheric pressure. If atmospheric pressure is higher, the waters will be squeezed together. If atmospheric pressure lessens, it allows the waters to grow bigger. The changes in the waters move a mechanical arm that shows higher or lower air pressure.

Either a mercury barometer or an aneroid barometer can be set up to make constant measurements of atmospheric pressure. Then it is called a **barograph** - may constantly record pressure on paper or foil wrapped around a drum that makes one turn per day, per week, or per month. Nowadays, many mechanical weather instruments have been replaced by electronic instruments that record atmospheric pressure onto a computer.

What happens if air pressure changes?
Why do my ears pop? If you've ever been to the top of a high mountain, you may have noticed that your ears pop and you need to breathe more often than when you are at lower altitude. As the mass of air around you decreases, the air pressure decreases. This causes your ears to pop in order to balance the pressure between the outside and inside of your ear. Since you are breathing fewer molecules of oxygen, you need to breathe faster to bring the few molecules into your lungs to make up for the deficit.

Activity: **Now test yourself by doing this activity.**

Choose the best answer.

1. Jocelyn was curious about the air pressure within a volleyball. She decided to place a well stretched balloon onto an inflation needle which she then inserted into a fully inflated volleyball. What did Jocelyn observe? The volume of the balloon will

   A. not change
   B. increase until all the air is released from the ball
   C. decrease as the air will be sucked into the volleyball
   D. increase until the air pressure is equal in the ball and the balloon

2. On a hot day in July, Neil walked off the concrete sidewalk onto the black asphalt street with bare feet. He quickly jumped back onto the concrete sidewalk when he felt the heat on his feet. As he stood on the sidewalk, he watched the heat shimmer off the asphalt. The heat appears to shimmer off the asphalt because the heat

   A. creates steam in the air.

   B. makes the air denser than the surrounding air.

   C. makes the air less dense than the surrounding air.

   D. causes the air to contract more than the surrounding air.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 12.

Summary

You have come to the end of lesson 12. In this lesson you have learnt that:

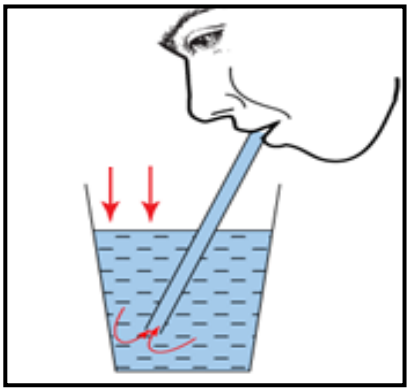
- atmospheric pressure is the pressing down of the atmosphere on the surface of the Earth.
- we do not feel the great weight of the atmosphere because of the two reasons; our bodies are built to withstand normal air pressure from within and air pressure acts equally in all directions.
- an altimeter is an aneroid barometer used to measure height above sea-level by recording the atmospheric pressure.
- the instruments used for measuring atmospheric pressure are aneroid barometer, mercurial barometer and barograph. An aneroid barometer can be used in place of a mercury barometer.

NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

Answer the following questions.

1. Look at the diagram on the right, and answer questions A and B.



   A. Explain what happens to the pressure inside the glass when you blow the straw.

   _____
   _____

   B. When one is sucking fluid with the use of straw, it creates a region of low pressure inside the straw, why?

   _____
   _____

2. Explain why we cannot feel the great weight of atmosphere.

   _____
   _____

3. When you are travelling up the Highlands from Lae, you will realize that the atmospheric pressure will slowly decrease and become thinner, explain why is this so?

   _____
   _____

4. Explain why the air pressure on the top is lower than at the foot of the mountain.

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activity

1. A
2. C

Lesson 13: Moving Air

Welcome to Lesson 13. This lesson will introduce students to the concept of moving air. You will complete two brief activities to determine which objects move in the wind and which do not.

Your Aims:

- define thrust, lift and drag
- discuss air movement and air pressure
- discuss how planes and birds fly
- describe how thrust, lift and drag affect the flight of an aeroplane

Air in Motion

Flight begins with air in motion. As an airplane moves through the air, its wings cause changes in the speed and pressure of the air moving past them. These changes result in the upward force called **lift**. To understand lift, you first have to understand how air (a gas) behaves under certain conditions.

In the early 1700s, a Swiss scientist named Daniel Bernoulli made a discovery. He noticed that when flowing air or water changed its speed, its pressure also changed. As you do these activities, can you figure out how the pressure changes?

Activity 1: Use your lips to rise up

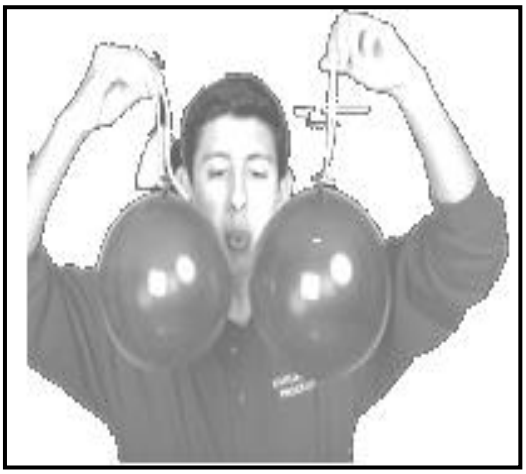
Hold a piece of paper between your thumb and fore finger, as shown. Now take a deep breath and blow over the paper.

What happens? So why did the paper lift up when you blew over it? How did that change the air pressure?

Air never pulls or sucks; it only pushes. It pushes on you every second, from every direction. This constant push is called **air pressure**.

Did you change the push of air on the top or bottom of the paper? When you blew over the top, the moving air had to squeeze between the paper and the air above it. As the air squeezed through, it sped up, lost pressure, and stopped pushing as hard. The still air below the paper had greater pressure and pushed the paper up.

Activity 2: Balloons that boggle



Blow up two balloons and tie each one to a string. Hold the balloons a few inches apart and try to blow them apart.

What happens?

Blow on the balloons in different ways and see what happens. Like everything else, the balloons are surrounded by air pressure.

When you blew between them, you changed the pressure. Either the air between them stopped pushing as hard, or the air on the outer sides began pushing harder.

Which do you think happened? As air squeezed between the balloons, it sped up, lost pressure, and stopped pushing as hard. So the higher pressure of the air on the outer sides of the balloons pushed them together. What would happen if you blew the outer side of one of the balloons?

Why does the air speed up?
When moving air encounters an obstacle a person, a tree, a wing—its path narrows as it flows around the object. Even so, the amount of air moving past any point at any given moment within the airflow is the same.

For this to happen, the air must either compress or speed up where its flow narrows. While air can be compressed more easily than water, freely flowing air acts much like water at least at relatively low speeds.

So when you "squeeze" a stream of air, two things happen. The air speeds up, and as it speeds up, its pressure, the force of the air pressing against the side of the object goes down. When the air slows back down, its pressure goes back up.

Because of conservation of mass, which states that mass is neither created nor destroyed, no matter what physical changes may take place. This means that if the area in which the air is moving narrows or widens, then the air has to speed up or slow down to maintain a constant amount of air moving through the area.

Why does the air pressure go down?
For a stream of air to speed up, some of the energy from the random motion of the air molecules must be converted into the energy of forward stream flow. The random motion of air molecules is what causes air pressure; so transferring energy from the random motion to the stream flow results in lower air pressure.

How Airplanes Fly

Almost everyone today has seen or heard of airplane. Many ask the simple question "what makes an aeroplane fly"?

The main reason planes fly is simple: wings force air downward, which in turn force the wing upward. Airplanes fly because they are able to generate a force called “lift” which normally moves the aeroplane upward.

Lift is generated by the forward motion of the airplane through the air. This motion is produced by the **Thrust** of the engine(s).

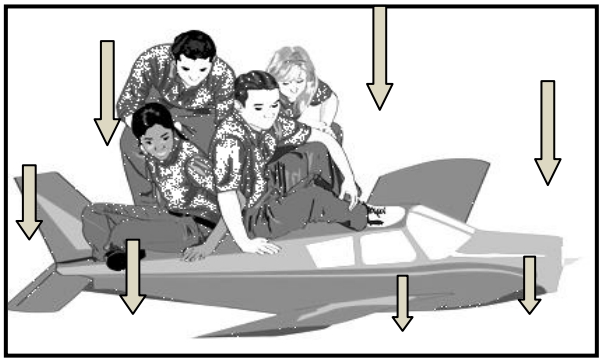
Drag is the force produced by the resistance of the air to the forward motion of the aeroplane. Swish your hand rapidly side-to-side and you will feel that resistance on your hand.

Weight is the force created by the pull of gravity toward the centre of the earth. You will feel the effect of this force if you jump up from the floor. Your weight will force you back down. When the Thrust produced by the engine(s) is greater than the force of drag, the aeroplane moves forward.

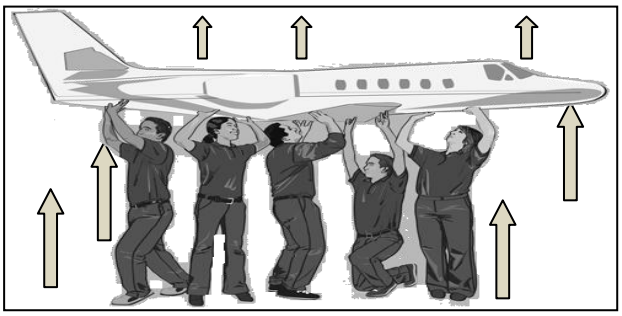
When the forward motion is enough to produce a force of Lift it is greater than the Weight, the aeroplane moves upward. While any part of the aeroplane can produce Lift, the most Lift comes from the wings.

The figure below is a simple diagram of the four forces acting on an aeroplane - weight, lift, thrust and drag.

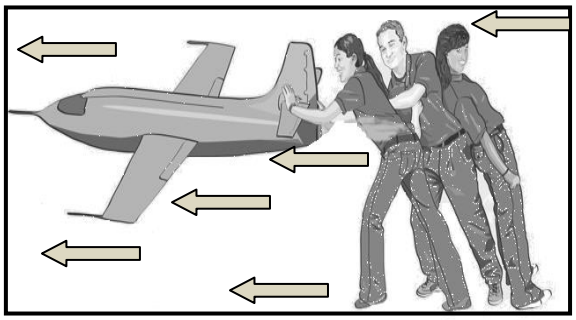
1. **Weight** is the force of gravity. It acts in a downward direction toward the center of the Earth.



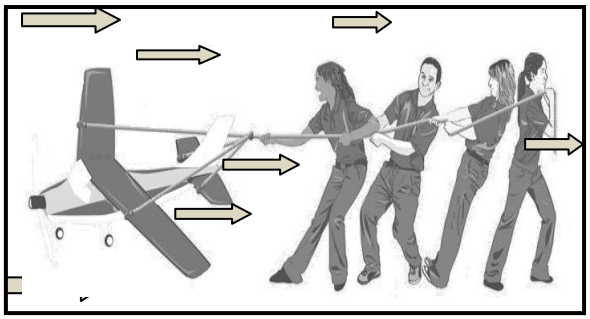
2. **Lift** is the force that acts at a right angle to the direction of motion through the air. Lift is created by differences in air pressure.



3. **Thrust** is the force that propels a flying machine in the direction of motion. Engines produce thrust.



4. **Drag** is the force that acts opposite to the direction of motion. Drag is caused by friction and differences in air pressure.



All four forces act on an airplane

When an airplane is flying straight and level at a constant speed, the lift it produces balances its weight, and the thrust it produces balances its drag. However, this balance of forces changes as the airplane rises and descends, as it speeds up and slows down, and as it turns.

How Birds Fly?

Most birds can fly. They do this by pushing through the air with their wings. The curved surfaces of the wings cause air currents (wind) to lift the bird. Flapping keeps the air current to create lifts and also moves the bird forward. Consider the motion of birds. A bird flies by use of its wings. The wings push air downwards. Since forces result from mutual interactions, the air pushes the bird upwards.

The flying bird

The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly.

Summary

You have come to the end of lesson 13. In this lesson you have learnt that:

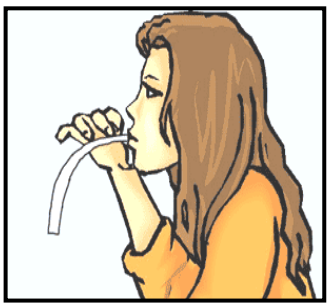
- air flows at normal speed and pressure through the open channel.
- air speeds up and its pressure drops when one side of the channel narrows.
- air speeds increases further and its pressure drops when both sides of the channel are narrowed.
- air speeds up and its pressure drops when one side of the channel narrows.
- there are four forces acting on an airplane – Weight, Lift, Thrust and Drag.
- weight is the force of gravity and acts in a downward direction towards the centre of the Earth.
- lift is the force that acts at a right angle to the direction of motion through the air and it is created by differences in air pressure.
- thrust is the force that propels a flying machine in the direction of motion and engines produce thrust.
- drag is the force that acts opposite to the direction of motion and is caused by friction and differences in air pressure.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE.

Practice Exercise 13

Choose the best answer.

1. Emily placed the short end of a letter-sized sheet of paper against her lower lip and then blew over the top of the paper.



The results of this experiment demonstrate:

A. Newton's third law
B. Bernoulli's principle
C. Einstein's theory of relativity
D. Galileo's gravitational theories

---

2. Daniel Bernoulli's experiments with fluids leads to an understanding about how

A. ships sail.
B. parachutes float.
C. hot air balloons fly.
D. airplanes create lift.

---

3. While Mrs. Peters' class watched planes take off at the airport, Wayne recalled that in order for a plane or bird to fly

A. gravity must equal drag.
B. lift must be equal to thrust.
C. thrust must be less than drag.
D. lift must be greater than gravity.

---

4. While at the zoo, Jonathan wondered why the Ostrich did not fly out of its enclosure. An ostrich cannot fly because

A. their necks are too long.
B. there is less pressure above their wings than below.
C. the force of gravity is less than the force of lift from their wings.
D. the force of gravity is greater than the force of lift that their wings can generate.

5. One afternoon, Mrs. Peter's class spent the afternoon at the airport watching the airplanes take off and land.

   The airplanes would speed down the runway until they lifted off the ground. Mrs. Peters once again reminded the class that planes lift off the ground because the

   A. air resistance is equal to the force of thrust.

   B. force of thrust is less than the force of gravity.

   C. air below the wing is moving faster than the air above the wing.

   D. air above the wing is moving faster than the air below the wing.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Practice Exercises 10 - 13

Practice Exercise 10

1. i) Troposphere ii) Stratosphere iii) Ionosphere

2. i) Nitrogen ii) Oxygen iii) Carbon dioxide

3. Ozone layer

4. Three oxygen molecules

5. i) Plant trees ii) Save paper

6. A layer of gases surrounding our planet.

7. The altitude increases and temperature decreases.

8. Holes are created by CFC gases released by refrigerators and aerosol spray cans.

Practice Exercise 11

A. (1) matter (2) molecules (3) atoms (4) weather (5) temperature

B.

1. **B**. The faster air moves, the less pressure it exerts.

2**.** **B**. The air from your mouth is too warm.

3. **D**. Type of material the balloons were made of and the amount of air in each balloon.

4. **A**. air takes up space. . **B.** amount of water in the pan.

Practice Exercise 12

1. A. The pressure inside the straw will increase.
   B. It is because pressure has been absorbed to the mouth.

2. It is because our bodies are built to withstand normal air pressure and from within.

3. Because the air pressure varies with height.

4. The great weight of the atmosphere decreases the higher you go above ground level.

Practice Exercise 13

1. **A**. Newton's third law

2. **B**. parachutes float.

3. **D**. lift must be greater than gravity.

4. **D.** the force of gravity is greater than the force of lift that their wings can generate.

5. **A**. air resistance is equal to the force of thrust.

REVISE TOPIC 3 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 3: Structure of the Atmosphere

Now, revise all lessons in this Topic and then do **ASSIGNMENT 6.** Here are the main points to help you revise.

Lesson 10: Layers of the Atmosphere

- Earth is believed to have formed about 5 billion years ago.
- We live at the bottom of an invisible ocean called atmosphere, a layer of gases surrounding our planet.
- There are three layers of the atmosphere:
  i) troposphere – where we live.
  ii) stratosphere – contains the ozone layer and ideal for planes to fly
  iii) ionosphere – a layer of free electrons and ions (reflects radiowaves).
- The ozone layer is important to life on earth because it absorbs biologically harmful ultraviolet radiation from the Sun.
- Three most important gases in the atmosphere are oxygen, nitrogen and carbon dioxide.
- The activities of people are causing harmful changes to the composition and structure of the atmosphere, which in turn affect living things.

Lesson 11: The Properties of Air

- Air is matter because it takes up space and has mass and so must be made up of molecules and atoms.
- Air can change temperature; we can feel the temperature of the air against our skin.
- There are properties of air: has weight or mass, showing pressure, has volume, has temperature, presence of water vapour, has velocity, has energy and has elasticity.

Lesson 12: Atmospheric Pressure

- Atmospheric pressure is the pressing down of the atmosphere on the surface of the Earth.
- We don't feel the great weight of the atmosphere because of the two reasons; our bodies are built to withstand normal air pressure and from within our bodies and air pressure acts equally in all directions.
- An altimeter is an aneroid barometer use to measure height above sea-level by recording the atmospheric pressure.
- Measuring atmospheric pressure are aneroid barometer, mercurial barometer and barograph.an aneroid barometer can be used in place of a mercury barometer.

Lesson 13: Moving Air

- Air flows at normal speed and pressure through the open channel.
- Air speeds up and its pressure drops when one side of the channel narrows.
- Air speeds increases further and its pressure drops when both sides of the channel are narrowed.
- Air speeds up and its pressure drops when one side of the channel narrows.

- There are four forces acting on an airplane – Weight, Lift, Thrust and Drag.
- Weight is the force of gravity and acts in a downward direction—toward the centre of the Earth.
- Lift is the force that acts at a right angle to the direction of motion through the air and it is created by differences in air pressure.
- Thrust is the force that propels a flying machine in the direction of motion and engines produce thrust.
- Drag is the force that acts opposite to the direction of motion and is caused by friction and differences in air pressure.

NOW DO TOPIC TEST3 IN YOUR ASSIGNMENT 6.

TOPIC 4

WEATHER

In this topic you will learn about:

- **convection currents**
- **precipitation**
- **cloud and cloud types**
- **weather charts**
- **weather forecasting and reporting**
- **climate**

INTRODUCTION TO TOPIC 4: WEATHER

The atmosphere is an important system that helps to regulate Earth's climate and distribute heat around the globe.

Climate

In this topic, discover the fundamental processes that cause **atmospheric* circulation*** and create **climate zones*** and weather patterns, and learn how carbon cycling between atmosphere, land, and ocean reservoirs helps to regulate Earth's climate.

If you are outside, you can tell if it is raining or windy, or sunny or cloudy. You can also tell how hot it is by taking a temperature reading.

Various forms of severe weather

Climate is sometimes referred to as "average" weather for a given area. Weather is what's happening right now or is likely to happen tomorrow or in the very near future. Some meteorologists say that "climate is what you expect and weather is what you get. Civil engineers utilize weather data when designing houses and other structures, to ensure that those designs are appropriate for the climate of their locations. Engineers also play an important role in designing products that enable people to more comfortable to the weather.

You should be able to ask yourself the following questions as you study Topic 3.

- What are convection currents, and precipitation?
- What are the different cloud types?
- How does climate differ from weather?
- What is the importance of weather forecasting?

In this Topic, you will find the answers to these questions and all other questions relating to weather.

Lesson 14: Convection Current

Welcome to Lesson 14. From our previous lessons you have studied air and how it behaves. In this lesson we will discover other behaviour of air when it gets hot and the effect it has on our planet. This behaviour of air is generally called Convection Current, and we will be looking at in more details in this lesson.

Your Aims:

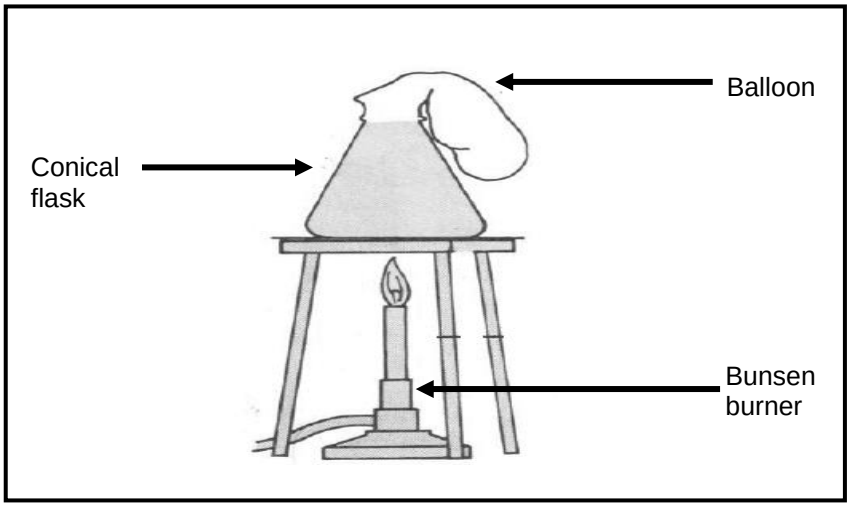
- explain the effect of Solar heating on land and water
- explain orographic and convectional current
- discuss land and sea breezes with down and up draughts
- state the tools used to measure wind speed and wind direction
- discuss how global winds are formed

Effects of Solar Heating on Land and Water

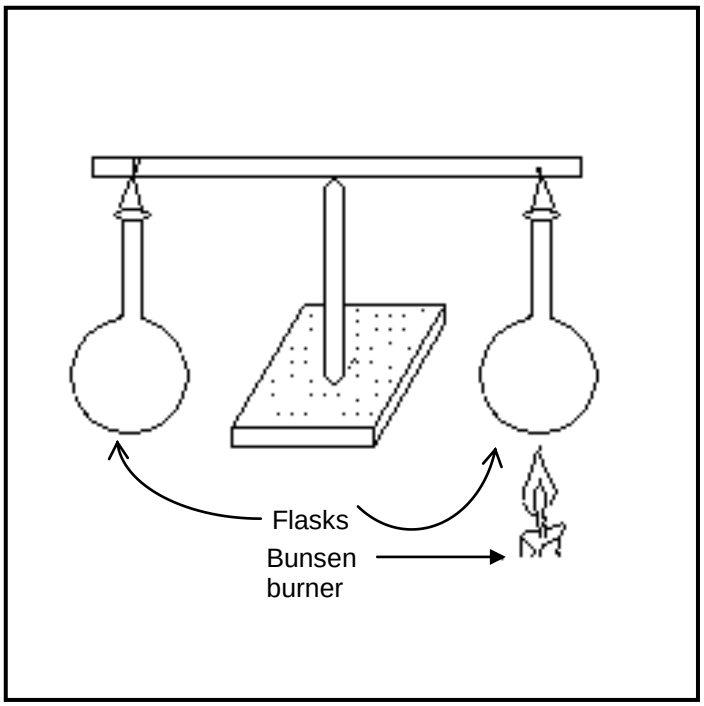
During the day heat from the sun normally called the Solar energy heats up the land. When the land heats up, usually the air above the land also heats up. Also during the night the water generally loses heat very slowly, this causes the air above the water to stay warm, while at night the land cools down very quickly resulting in the air above the land to be cooler.

What happens to air when it is heated?
When air is heated the particles move faster and farther apart, hence this causes the air to expand.

This also reduces its pressure so warm air has a low pressure and cold air has a high pressure. The low pressure air is lighter than the same volume of cold air which is at a high pressure. This heating and cooling of the air creates a flow of air currents. There are generally two types of air currents, **orographic current** and **convection current.**



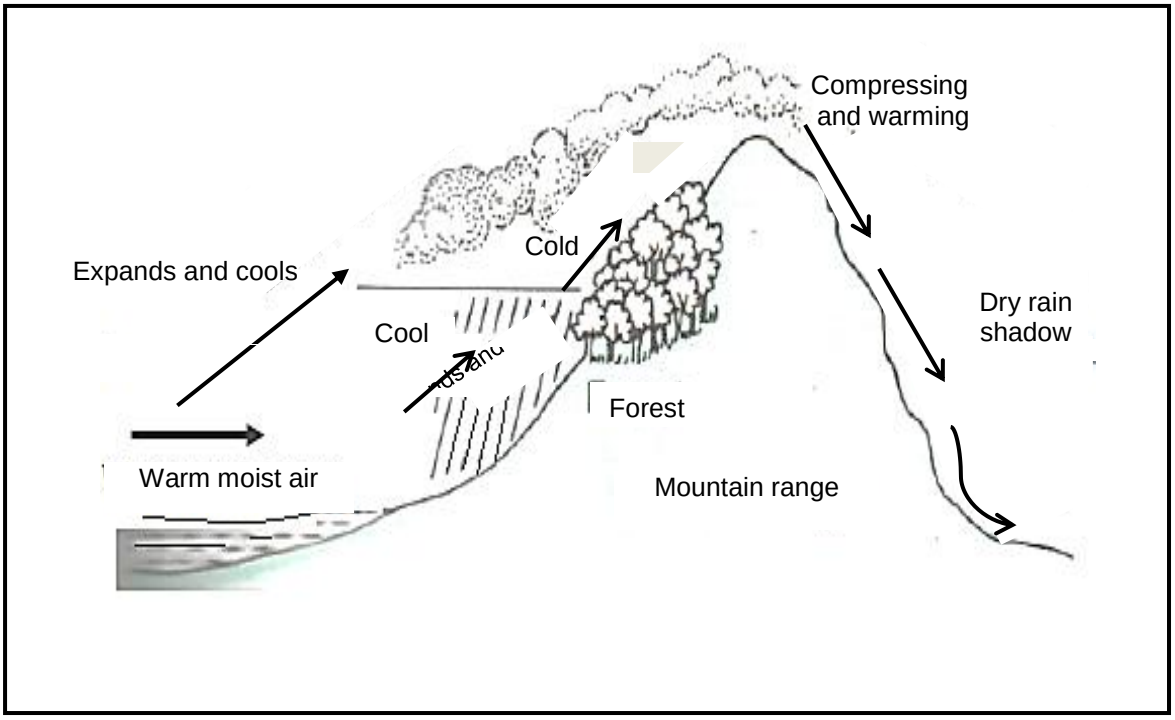
As the flask warms air expands into the balloon causing it to inflate.



The air is heated, it expands and moves out causing the heated flask to be lighter and it moves up the balance

Orographic Current

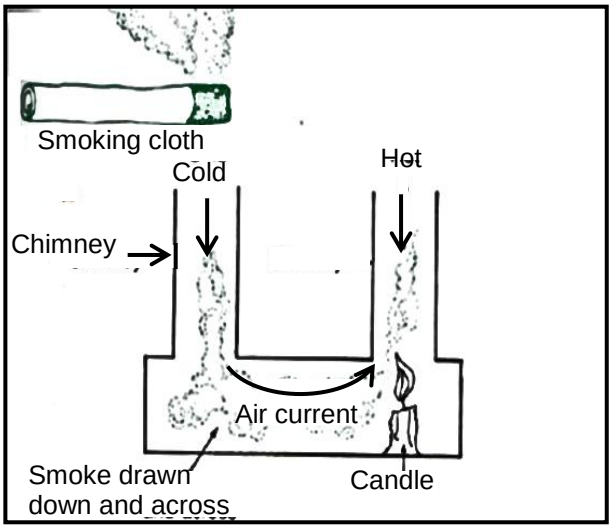
This is the air current that is formed by the lifting or rising of warm moist air over a mountain barrier or high ground. The warm moist air is blown towards the land and is forced up and over a mountain. As the air rises over the mountain the pressure gets less resulting in the air getting cooler and it condenses and falls as rain, once the air passes on to the other side it becomes warm and dry again.



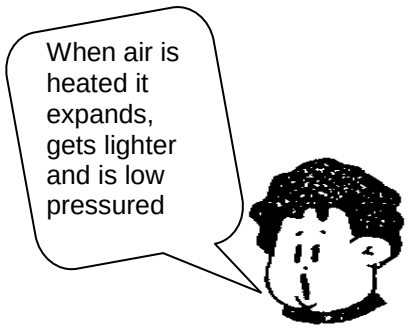
Orographic current

Convectional Current

The circulation of air caused by the movement of hot air is called **convection current.** When air gets warm, it becomes less dense and lighter, so it is pushed up by cold dense air which sinks to the bottom. Hence we have the convectional current were air is caused to move around by the movement of hot air.



Convection chimney



The presence of convection current can be shown using a convection chimney as shown above. Smoke is drawn down the chimney by the cold air. As it sinks down because it is heavy it pushes out the hot air that is been heated by the candle.

Activity1.1: **Now test yourself by doing this activity.**

Answer all questions according to the given instructions.

1. Define Convection Current?

   _____

2. List the different properties of air when it is heated?

   _____

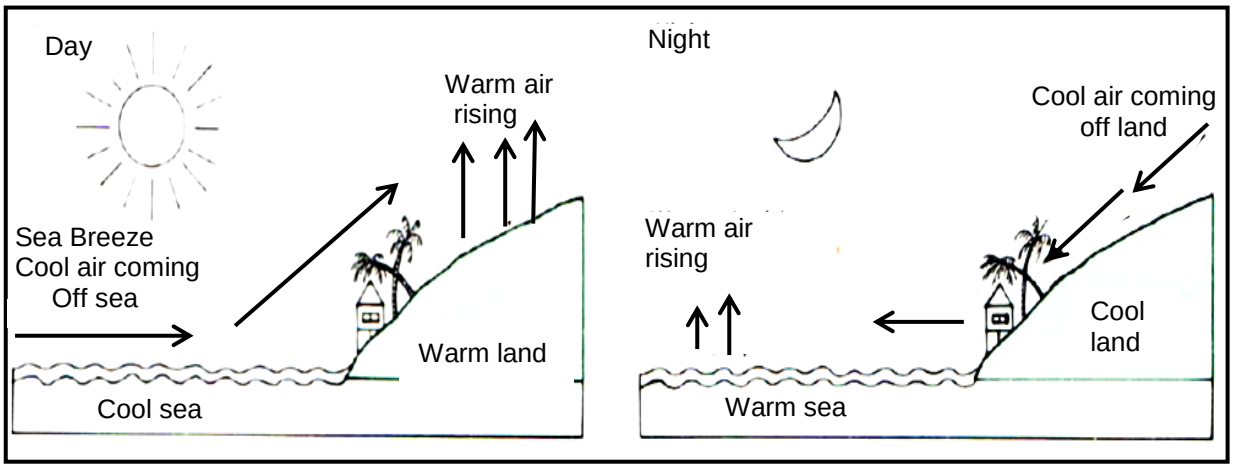
Effects of Convectional Current

The movement of cold high pressure air to replace warm low pressure air is called **wind** or **breeze.** And it occurs on a large scale as well as on a small scale.

Land and sea breeze

During the day solar energy heats up the land more quickly than the sea and water. As the land becomes hot the air above it becomes heated also, therefore it expands and rises. While cool air from the sea comes in to take its place. Subsequently, during the night the land normally cools down very quickly than the water. Therefore the warm air over the sea expands, and is being pushed up by the cooler air from the

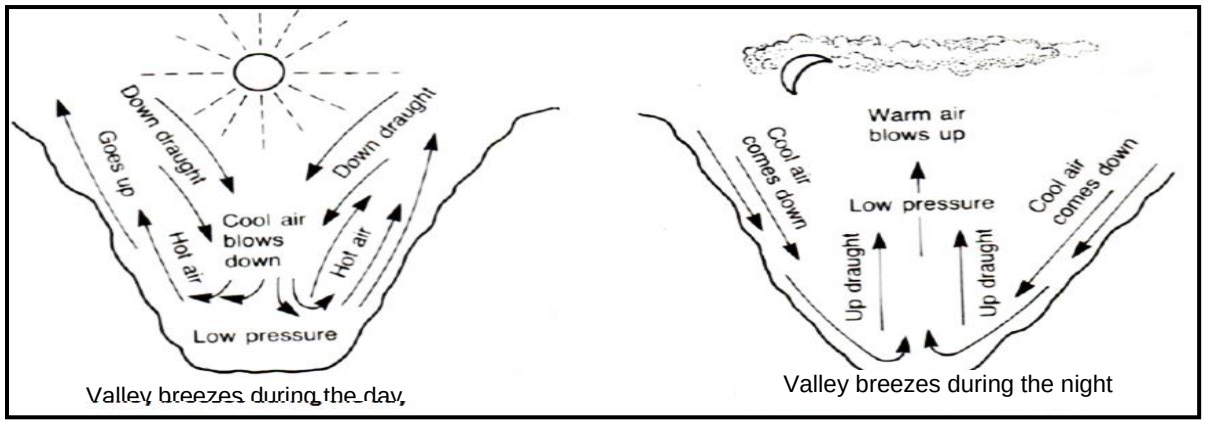
land which moves out to sea. In this way we have our land and see breezes blowing during the day and night.



Land and Sea breezes

Mountain and Valley Breezes

During the day the floor and sides of the valley heats up and warm air expands up along the slopes while cool air moves down the centre of the valley. The cool, high pressure air that blows down the centre of the valley is called the **down draught**. While at night time, the mountain valley and the floor normally cools faster, resulting in cool air moving down from the sides lifting and pushing the warm air from the centre of the valley. The warm low pressure air that rises up the centre of the valley is known as the **up draught.**



Valley Breezes

Tools for Measuring Wind Speed and Direction

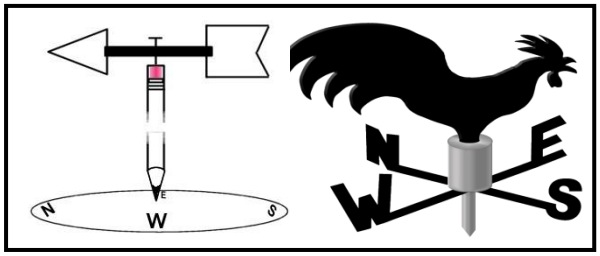
Anemometer

Wind speed can be measured using an **anemometer.** It consists of three or four cups attached to short rods. As the wind blows, it pushes the cups, which turn the shaft. The number of turns per minute is translated into wind speed.

Anemometer

Wind vane

A **wind vane**, also called a **weather vane**, is a tool for measuring wind direction. The direction the wind is blowing from causes the wind vane to spin and point in that direction. The arrow will point to the direction the wind is blowing from so if it is pointing to the north, it means the wind is coming from the north.

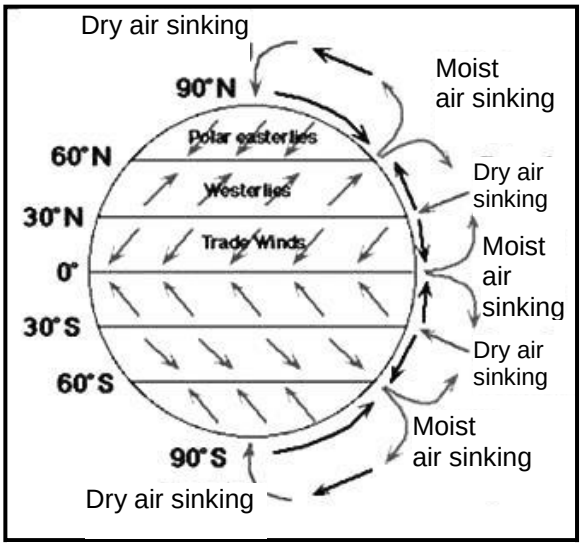


Different types of wind vane

Global Winds

Winds are really large convection currents caused by the uneven heating of the earth's surface. The earth's surface has warm areas called the **tropics** and cold areas called the **poles**. Air above the tropics and the equator is warmer than in other regions and so it has a lower pressure. While at the poles, the temperature is cooler and so air above the poles has a high pressure and is denser. This creates a flow of air, where cool air from the poles flow to replace the warm from the tropics and equator, resulting in our global wind systems.

Apart from the heating of the land and ocean there is also another important factor that affects the wind patterns. And that is the rotation of the earth's surface as it spins along its axis. The rotation of the earth causes the heating of the earth's atmosphere at different times of the year giving rise to complicated world wind patterns.



Rotation of the earth's surface as it spins along the axis

Activity 1.2: Now test yourself by doing this activity.

Answer all questions according to the given instructions.

1. What is the difference between up draughts and down draughts?

   _____
   _____

2. Explain how the rotation of the earth affects the global wind patterns?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 14.

Summary

You have come to the end of lesson 14. In this lesson you have learnt that:

- all air expands when heated.
- warm air is less dense than cool air.
- convection current is formed when less dense warm air is forced up by more dense cool air around it.
- the movement of cold high pressure air to replace warm low pressure air is called wind and is caused by the uneven heating of the earth's surface.
- global wind patterns are affected by the rotation of the earth.
- weather instruments such as the anemometer and wind vane measures the wind speed and direction respectively.

NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Answer the following questions.

1. Identify the two main types of air current.
   i) _____
   ii) _____

2. What is convection current?
   _____
   _____
   _____

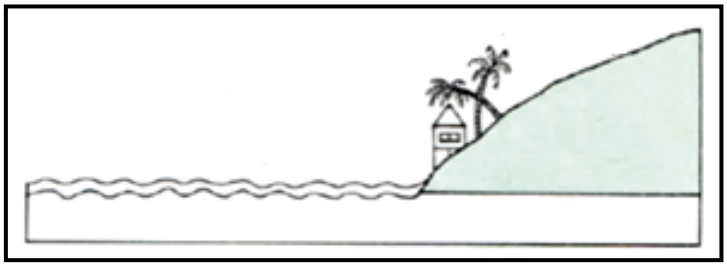
3. State the three main effects of convection current on the earth.
   i) _____
   ii) _____
   iii) _____

4. The instrument used to measure:
   i) Wind Speed _____
   ii) Wind Direction _____

5. State the two main factors that affect global winds.
   i) _____
   ii) _____

6. Briefly explain how global winds are formed.
   _____
   _____

7. Label and indicate the flow of high and low pressure air during the day.



CHECK YOUR WORK. ANSWERS ARE AT THE END OF THE TOPIC 4.

Answers to Activities

Activity 1.1

1. It is circulation of air caused by the movement of hot air.

2. It gets lighter and expands/ is low pressured

Activity 1.2

1. Down draught is the cool, high pressure air that blows down the centre of the valley during the day, while up draught is warm low pressure air that rises up the centre of the valley during the night caused by convectional currents.

2. The rotation of the earth causes the heating of the earth's atmosphere at different times of the year giving rise to complicated world wind patterns.

Lesson 15: Precipitation

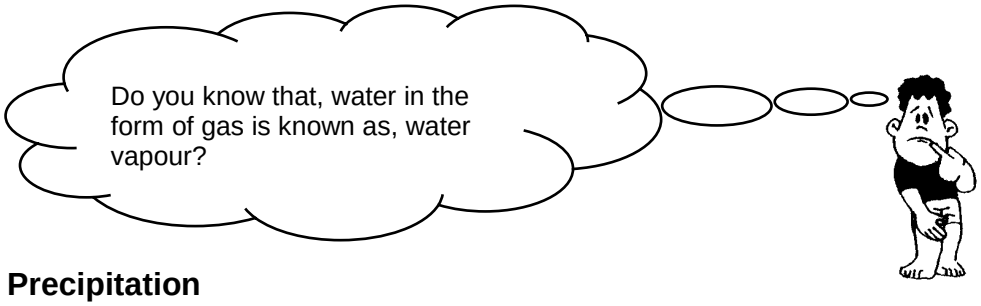
Welcome to Lesson 15. In our last lesson you studied what happens when air gets hot. You also learnt the movement of air from a more dense area to a less dense area hence creating our local and global wind systems. In this lesson we will learn the effect caused by the air in our planet. This time we will look more closely air currents that contains water and what happens when temperature and altitude changes. In order to learn this you, we will study the word called precipitation.

Your aims:

- define precipitation
- discuss forms of precipitation
- distinguish orographic precipitation from convection precipitation

Precipitation

Precipitation is the release of all water and solid water particles from the air. It occurs when water is carried as a gas by air currents into the atmosphere. This water gas cools and condenses to form small drops of liquid which we see as clouds. When the air can no longer hold this droplet of water, releases it back down to the ground.



Forms of Precipitation

Precipitation can occur in different forms:

1. **Rain** is the most common form of precipitation. It precipitates of liquid drops of water. It forms when water vapour joins together and in doing so, they change state from gas to liquid. When they are large enough and with the force of gravity they fall to the ground as raindrops.

2. **Snow** is another form of precipitation where water vapour in the atmosphere freezes into ice crystals and falls to the ground in the form of flakes. Snow is formed when the temperature in the cloud is below 0°C, causing ice crystals to form in the cloud to grow and fall to the ground without melting.

3. **Hail** is the form of precipitation consisting of small balls of harden snow that falls as rain. Hail is formed when a frozen raindrop falls through warm air and a layer of water freezes around it, and if the piece of hail is again carried up by

strong winds, the process will repeat again resulting in many layers being built. Then becomes heavy and falls to the ground as hailstone.

4. **Dew** most commonly occurs during evenings or early mornings. As the warm air cools it is able to hold less water vapour and the excess condenses on the nearest surface, such as the plants.

5. **Frost** is when temperature is below freezing point, resulting in the deposit of ice crystals on the earth's surface. Frost forms when the temperature is below 0°C, which causes the water vapour to condense directly from gas to solid **crystals***.

Hail Stones Dew

There are two types of precipitation.

1. **Orographic Precipitation** is when moist ocean air, flowing inland from the coast, meets an area of high elevation, such as a mountain the air is forced to rise. As the air rises and cools, the moisture within it condenses and falls as rain or snow on the windward side of the mountains—the side facing the ocean. The other—leeward—side receives relatively little precipitation.

2. **Convectional Precipitation**
It occurs due to the formation of convection currents.

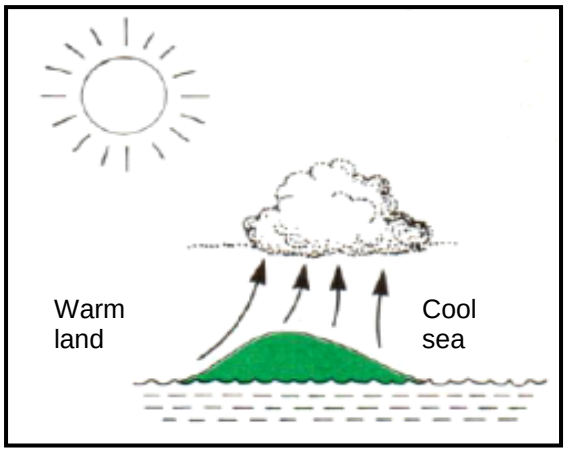
When does convectional precipitation occur?

The sun's heat vaporizes water and draws it from earth's surface into the atmosphere. As the vapour cools, it falls back to the earth as rains, snow and other precipitation.

You can imagine: when you make coffee or tea, water is put into a pot and is heated. You can always see water drops on the pot cover. When the water is boiled, some is vaporized and leave the surface into the air. Water vapour is really hot and is turned into water again when touching cold pot covers.

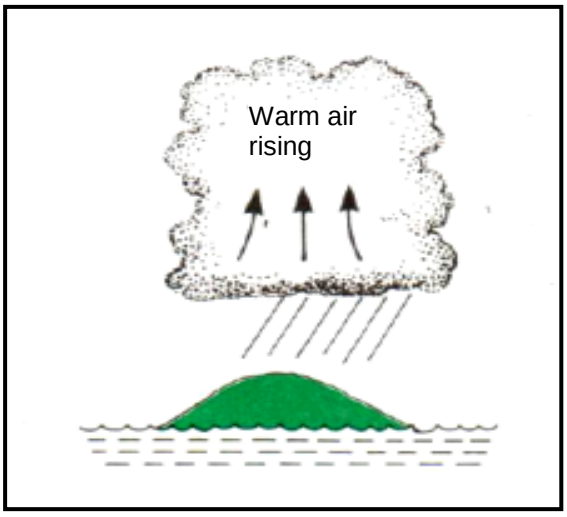
For example let us look at an isolated island.

a) The island gets heated air above it and this sets up a convection current. As the warm air rises, it cools due to low pressure, and forms clouds.



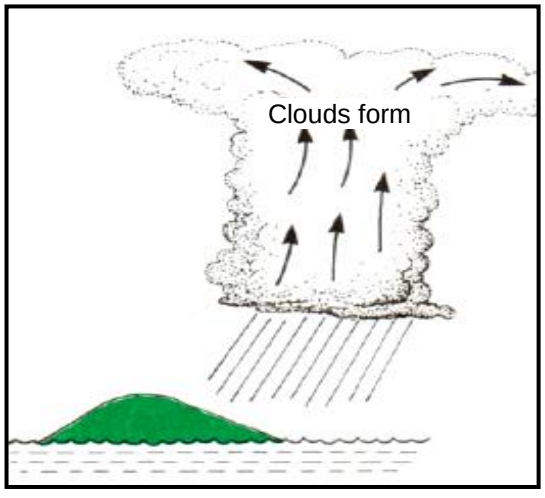
Warm land and cool sea island

b) As the warm air cools, water in the air condenses and collects to form clouds.



Air condensation

c) When droplets of water have collected together and have grown in size as a cloud, it falls back as rain.



Formation of Rain

Altitude is the height above sea level. Therefore as the mountain causes the air to move to a high altitude water vapour in it cools, condenses and the tiny water droplets that formed to produce clouds. As the air gets cooler still, more and more droplets are formed. They join together until they become so big that the air can no longer support them, and they fall as rain. The higher the altitude the cooler the air gets.

Remember, temperature is another factor that determines the type of precipitation that falls. When the temperature of the atmosphere is above freezing point we have rain. When it is below 0^{o}C it results in hailstorm.

Activity: **Now test yourself by doing this activity.**

Answer all questions according to the given instructions.

A. Explain the term precipitation.

_____

B. List the forms of precipitation that can occur in Papua New Guinea.

_____

_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 15.

Summary

You have come to the end of lesson 15. In this lesson you have learnt that:

- precipitation is the release of all water and solid water particles from the air.
- precipitation occurs when air can no longer hold its water.
- rain, snow, hail, dew and frost are all different forms of precipitation.
- orographic precipitation is caused by warm moist air from the coast that has been forced over the mountains.
- convectional precipitation is caused by warm air rising above the land.

NOW DO PRACTICE EXERCISE 15 ON THE NEXT PAGE.

Practice Exercise 15

Answer the following questions.

1. Define precipitation.
   _____

2. State the two types of precipitation.
   i) _____ ii) _____

3. List four different forms of precipitation.
   i) _____ ii) _____
   iii) _____ iv) _____

4. State the difference between orographic and convectional precipitation.
   _____
   _____

5. Explain how altitude affects precipitation.
   _____
   _____

6. Describe the following terms:
   i) Rain _____
   ii) Snow _____
   iii) Hail _____
   iv) Frost _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activity

A. Precipitation is the release of all water and solid water particles from the air.

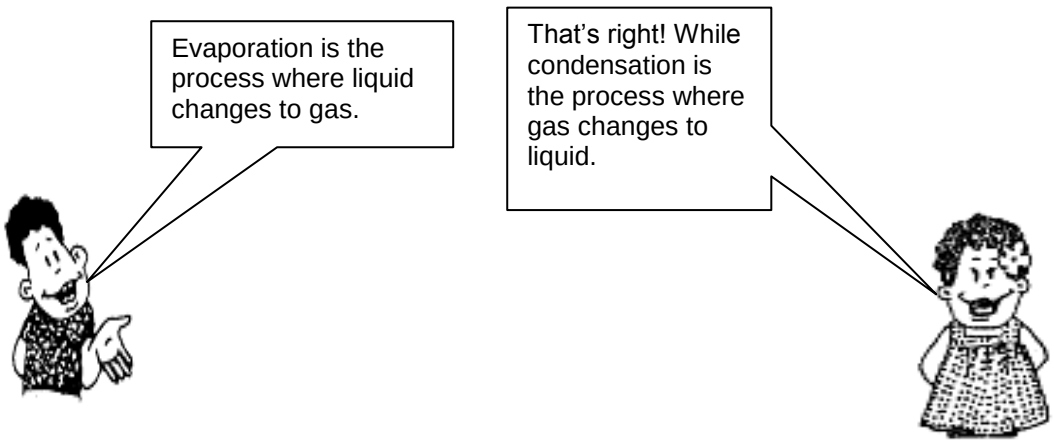
B. Rain/Dew/Frost

Lesson 16: Cloud and Cloud Types

Welcome to Lesson 16. We have learnt that the heat from the sun continuously evaporates the water from the surface of the earth every day. The heat changes water into water vapour. The water vapour is then carried by air currents, and as you have discovered in the last lesson on precipitation, this water vapour in the atmosphere normally condenses to form clouds. Therefore in this lesson we will look at clouds and how they are formed and the different cloud types.

Your Aims:

- explain cloud formation
- explain how droplets of water end up as clouds in the atmosphere
- identify the different types of cloud
- identify cloud cover symbols

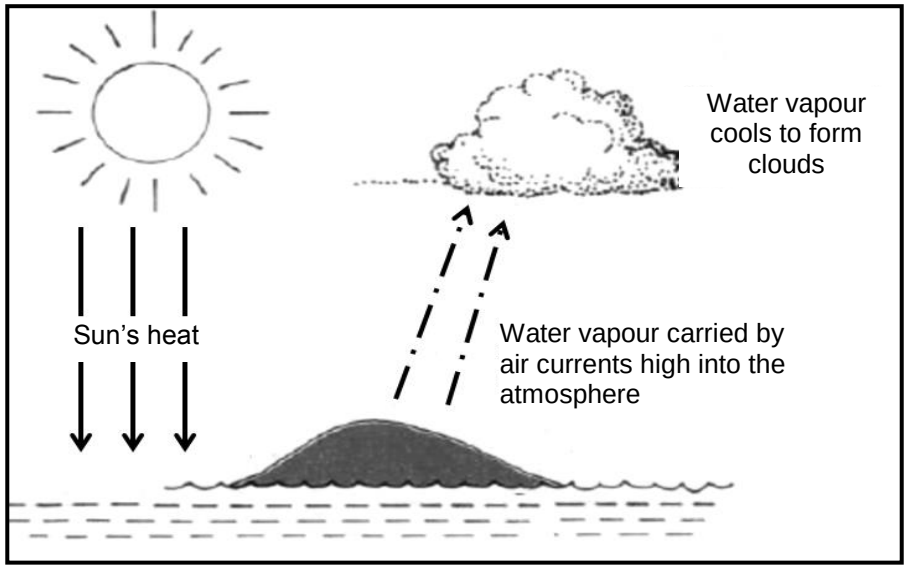


How do Clouds Form?

When water vapour evaporates from the sea and rivers, it is carried by air currents high into the atmosphere. As it rises the water vapour in it cools and condenses and the tiny water droplets that form produce clouds. As the air gets cooler still, more and more droplets are formed. They join together until they become so big it no longer support them and they fall as rain or other forms of precipitation.

In order for clouds to form, water vapour can only condense if there is a suitable surface, such as salt, smoke or dust particle, on which the particle can come together.

Clouds are formed by the droplets of water vapour which condenses to form small droplets of liquid water.



The formation of clouds

Cloud types

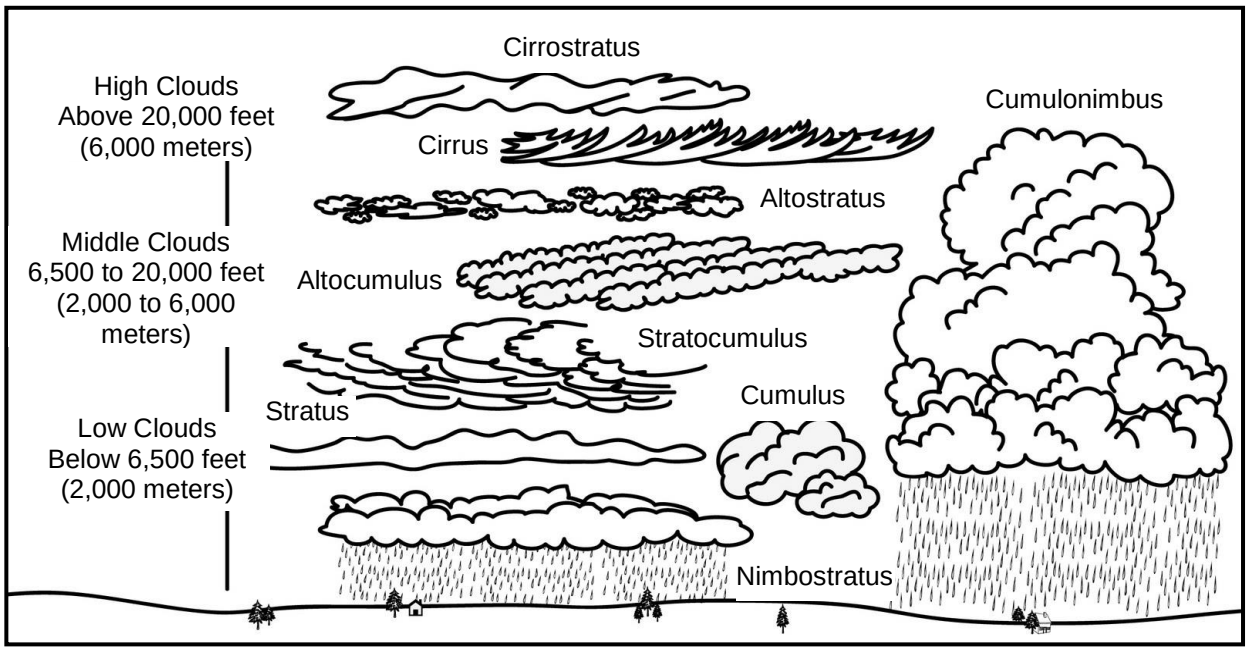
Clouds are classified according to their shape and the altitude at which they are formed. The three main types of clouds are described below.

1. **Cirrus clouds**
   Are delicate and white feathery clouds which do not hide the sun. They usually form at an altitude of 8 kilometres.
2. **Cumulus clouds**
   Are dense and white clouds with flat base. They look like heaps of cotton wool. Normally they can hide the sun causing shadows and they form at low altitudes around two and a half kilometres above the earth's surface.
3. **Stratus Clouds**
   Are layered clouds, which form a sheet covering the whole sky. They cause grey skies and form at low altitudes around two and a half kilometres.

The three main types of clouds can be further divided into ten different types of clouds as shown in the table below.

Names of Common Cloud Types		
Type	**Name**	**Comments**
High Clouds	Cirrus Cirrostratus Cirrocumulus	Usually good weather for at least 24 hours. Rain likely within 24hours Thunder storms possible
Middle Clouds	Altocumulus Altostratus	Thunderstorms likely Rain developing or easing
Low Clouds	Stratus Nimbostratus Stratocumulus Cumulus	Drizzle, Steady rain Light rain Fine weather, unless growing very large
Clouds with high vertical development	Cumulonimbus	Thunderstorm clouds (Brief heavy rain, hail or snow)

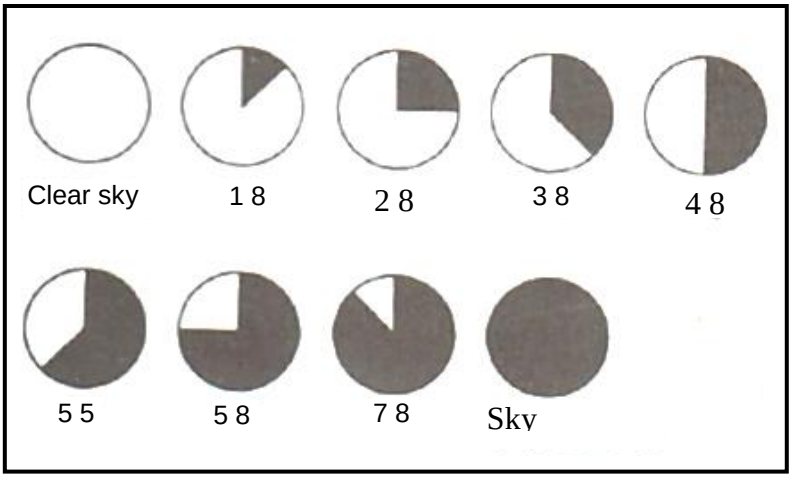
Cirro - is the prefix for high clouds.
Alto - is the prefix for middle-level clouds.
The prefix nimbo - and the suffix - nimbus mean that the cloud is producing precipitation.



Cloud cover

Symbols are used to indicate how much of the sky is covered by cloud. Because of how much the cloud covers over the sky generally helps in predicting and forecasting the weather conditions of the day symbols are given. Normally the amount of cloud cover over the airport is indicated by colouring in the circle.

The following symbols are used to indicate cloud cover.



Cloud cover symbols

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

A. Name the three main types of cloud

_____

_____

B. What is cloud cover?

_____

_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Summary

You have come to the end of lesson 16. In this lesson you have learnt that:

- clouds are made up of water vapour and forms when the air temperature or the air pressure drops.
- before clouds are formed condensation must take place.
- there are three main types of clouds; cirrus- delicate white feathery clouds, cumulus – dense, white clouds with white flat base and stratus layered clouds.
- these three types of clouds are further divided into ten different clouds.
- cloud cover can be shown using symbols to indicate how much of the sky is covered. And is often used to forecast weather.

NOW DO PRACTICE EXERCISE 16 ON THE NEXT PAGE.

Practice Exercise 16

Answer the following questions.

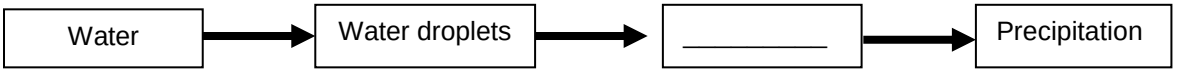
1. Briefly in your own words describe how clouds are formed.
_____

1. Identify correctly which type of clouds does the following pictures show:

i)_____

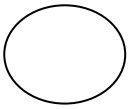
ii)_____

2. Complete this process.



3. Fill in the table with the correct type of cloud.

Cloud Type	Description
	forms a sheet over the sky
	looks like cotton wool
	high clouds.

4. What does this cloud cover symbol  mean?
_____

5. Differentiate the following: cirrocumulus, stratocumulus and altocumulus clouds.
_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activity 1.1

A. Cirrus clouds, Cumulus clouds and Stratus clouds
B. How much of the sky is covered with clouds.

Lesson 17: Weather Charts

Welcome to Lesson 17. In the previous lesson, you learnt about how clouds formed and its different types. In this lesson you will learn about the difference between weather and climate and how to read weather charts.

Your aims:

- define weather, climograph, and meteorologist
- discuss weather charts
- discuss weather symbols, isobars and weather instruments.

The weather settings of an area are controlled by the temperature, rainfall, wind and evaporation that an area encounters each day. The weather has an abrupt result on the lives of people. The type of house they built, clothes they wear, food they produce and work they do.

What is Weather?

Weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity. Weather is not the same everywhere. It may be hot, dry and sunny where you live, but cloudy, raining or even snowing in other places.

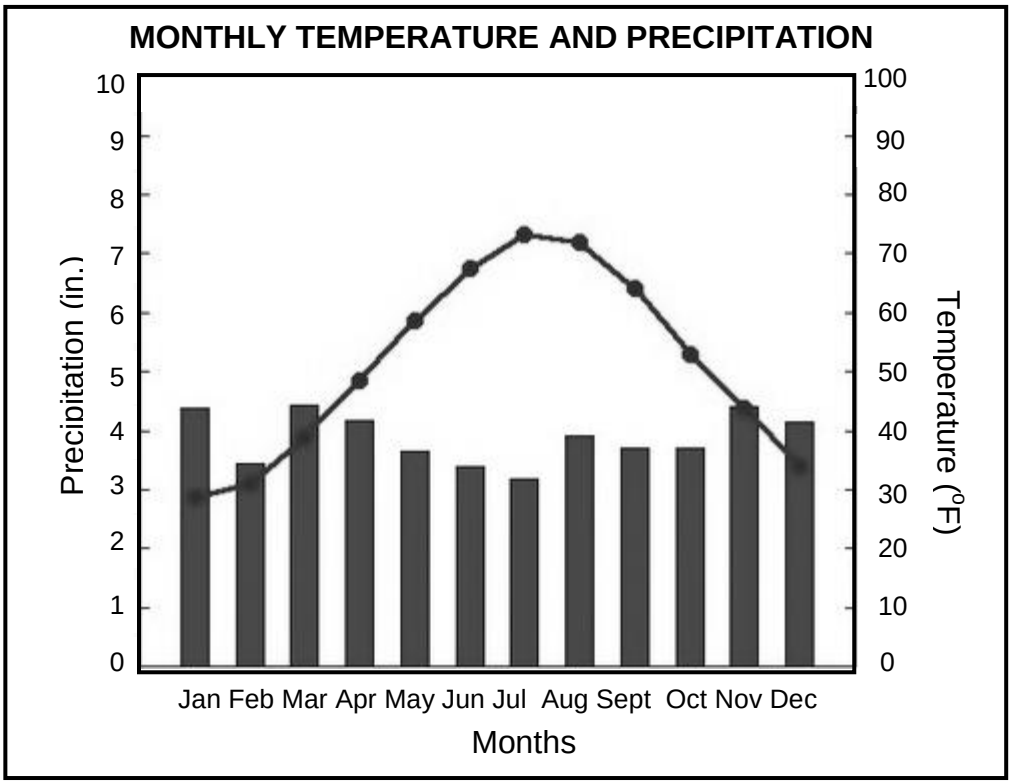
Atmospheric scientists are those who forecast the weather known professionally as operational meteorologists. They study information on air pressure, temperature, humidity, and wind velocity to make short range and long range weather forecasts.

What is Climate?

Climate is the average weather pattern over many years. The climate in the Antarctica are quite different than the climate of Papua New Guinea which is in the tropic.

Different weather data can be represented by drawing graphs called **climograph,** which shows the monthly temperature. Most climographs show this information over an annual span. It is a dual-purpose graph, showing two different kinds of information.

1. A **bar graph** shows how much precipitation a given place receives during a period of time.
2. A **line graph** shows the temperature for the same place during the same period of time.



Climograph

A bar graph shows how much temperature and precipitation a given place receives during a period of time.

Weather is essential. People understand weather changes before they are forecasted. Weather information are collected and recorded by trained observers, crews of ships and aeroplanes and from **satellites***.

In Papua New Guinea, most weather stations measure the maximum and minimum temperatures, rainfall, and the wind speed and direction. A **weather station** is a place where instruments are set up to measure the weather. It must be set up outside in an open area where the instruments will be fully exposed to the weather.

Meteorologists use a variety of tools to gather information about weather and climate. Some instruments are thermometers which measure air temperature, anemometers which gauge wind speeds, and barometers which provide information on air pressure. These instruments allow meteorologists to gather data on the Earth's surface. Collecting data from other sources helps to create a more descriptive picture of weather.

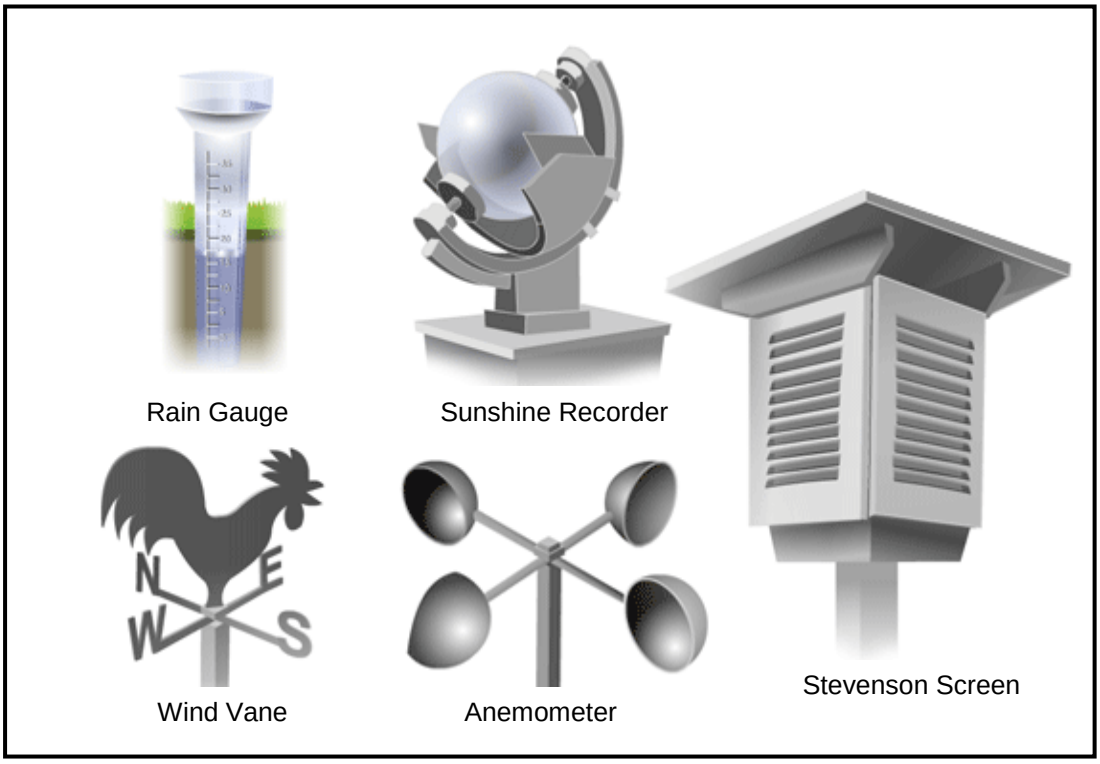
Instruments used to measure weather

1. A **rain gauge** is an instrument used by meteorologists and hydrologists to measure precipitation (e.g. rain) in a certain amount of time. It usually measures in millimetres.

2. A **sunshine recorder** is a device that records the amount of sunshine at a given location. The results provide information about the weather and climate of a geographical area.

3. A **wind vane** (or weathercock) is an instrument for showing the direction of the wind. They are typically used as an architectural ornament to the highest point of a building.

4. An **anemometer or wind meter** is a device used for measuring wind speed, and is a common weather station instrument. The term is derived from the Greek word anemos, meaning wind, and is used to describe any air speed measurement and is an instrument used in meteorology or aerodynamics. A **Stevenson screen** or **instrument shelter** is an enclosure to shield meteorological instruments against precipitation and direct heat radiation from outside sources, while still allowing air to circulate freely around them.



Weather instruments

To get accurate and reliable information, reading of weather instruments should be made each day. This allows information on weather to be compared between places. We received weather information from different sources by telephone or radio at the National Weather Service at Jackson's Airport in POM. Information is directly placed on daily maps and made available to airline pilots, newspapers, and radio and television stations.

Here is an example of a weather forecast.

The 7 day weather forecast summary for Port Moresby:

Taking a look at Port Moresby over the coming week and the average daytime maximum temperature will be around 31^{o}C, with a high for the week of 34^{o}C expected on the afternoon of Thursday 19th. The average minimum temperature will be 24^{o}C, dipping to its lowest on the morning of Saturday 21st at 22^{o}C. The week will have some days seeing a little precipitation and some days with rain. The current forecast indicates Monday 21st will have the most precipitation with an accumulation of around 23.00mm. On the whole winds are likely to be moderate.

Symbols Used In Weather Maps

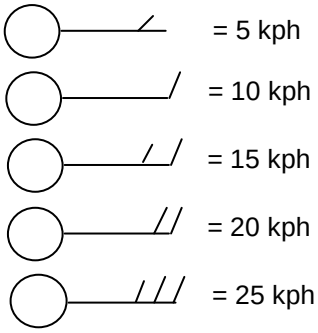
Information	**Notes and Symbols**
Airports	Airports are represented by a circle. 

Wind

Wind is indicated by an arrow. The feathers at the end of the arrow indicate the speed of the wind in kilometres per hour (kph).

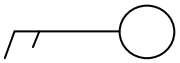
A half feather

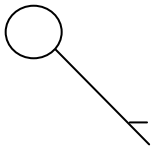
A full feather



The head of the arrow ends in the circle and shows the direction from wind is blowing.

For example:

Wind from the west 

Wind from the south-east. 

Clouds The amount of cloud covering the airport is indicated by colouring in the circle.

Example:

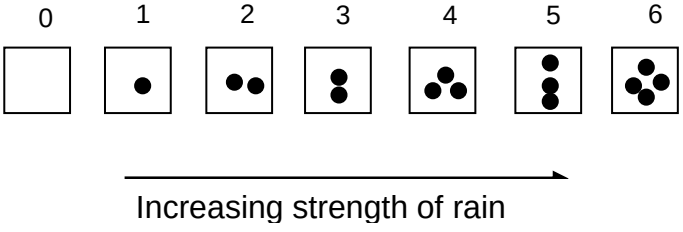
 = clear sky with no clouds

 = 2/8 of the sky covered by clouds

 = 4/8 of the sky covered with clouds

---

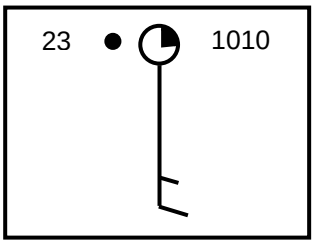
Rain The presence and strength of rain is indicated by a series of dots which appear on the left side of the airport circle.



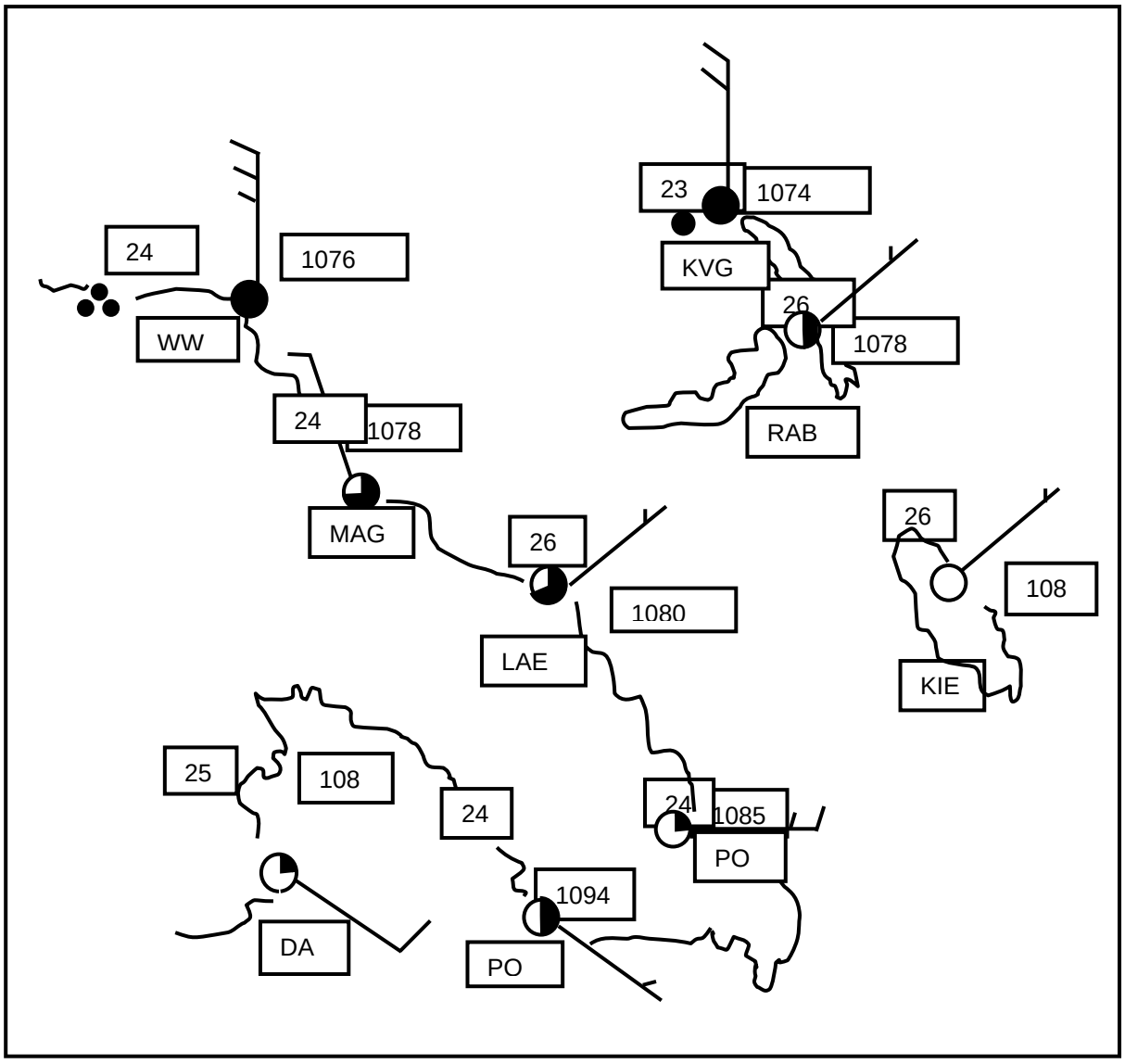
Temperature The temperature in ^{o}C is written to the top left of the airport circle.

Air pressure The air pressure is written in millibars at the top of the airport circle.

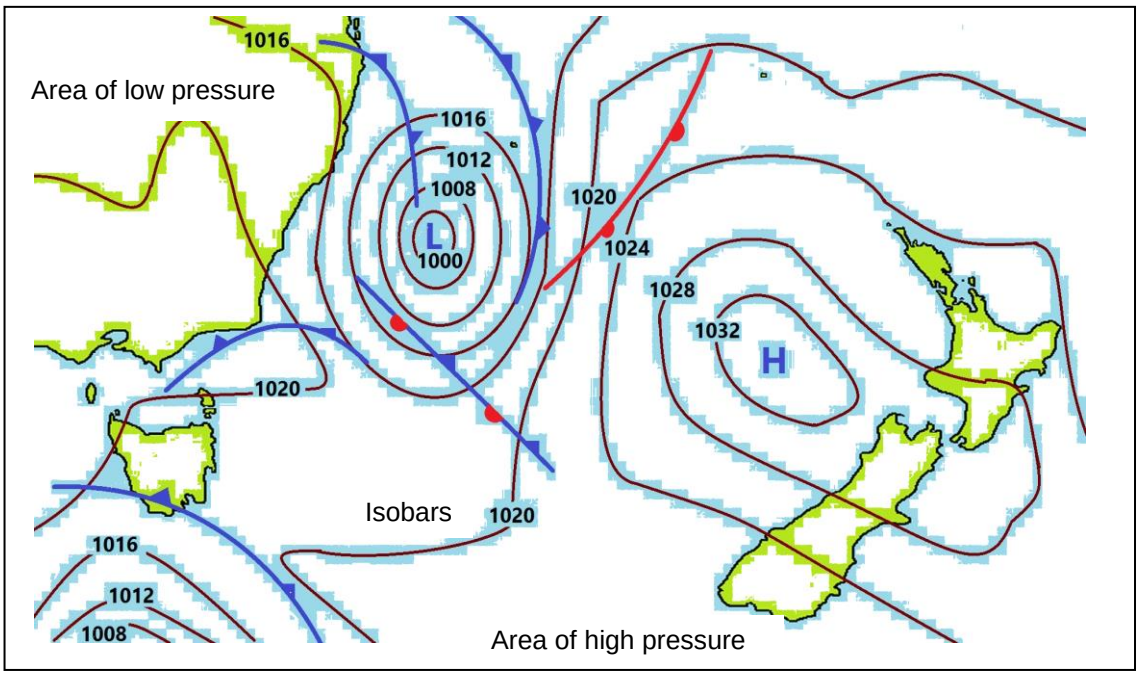
Thus if a weather map shows:



It would mean that at that time the airport's weather was:
Wind about 15 kph from the south.
Air temperature 23^{o}C.
Air pressure 1010 millibars.
Light rain and about ¼ of the sky covered by clouds.



Map showing the weather conditions at several airports in Papua New Guinea



Isobars can be drawn by connecting places with similar pressure

Summary

You have come to the end of lesson 17. In this lesson you have learnt that:

- people who study weather are called meteorologists.
- a bar graph shows how much precipitation a given place receives during a period of time.
- a line graph shows the temperature for the same place during the same period of time.
- weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity.
- climograph shows the monthly temperature and precipitation of a certain place in the world at a given period of time.
- weather instruments must be set up in an open area where they will be fully exposed to the weather.
- weather station is a place where instruments are set up to measure the weather.

NOW DO PRACTICE EXERCISE 17 ON THE NEXT PAGE.

Practice Exercise 17

A. Identify the choice that best completes the statement or answers the question.

1. The average weather pattern in a place over many years is called_____.

   A. climate
   B. weather
   C. dew point
   D water cycle

---

2. The most common form of precipitation is _____.

   A. hail B. rain
   C. sleet D. snow

---

3. How are the weather settings of an area controlled? By

   A. evaporation, wind, snow and storm
   B. temperature, condensation, hail and storm
   C. temperature, rainfall, wind and evaporation
   D. condensation, temperature, rainfall and wind
   E. condensation, temperature, rainfall and wind

---

4. Where can a weather station be set up?

   A. In a dark place.
   B. In an open area where the instruments will be hidden.
   C. Outside and open area where the instruments will be fully exposed the weather.
   D. Outside in an open area where the instruments will not be fully exposed to the weather.

5. An instrument used by meteorologists and hydrologists to measure precipitation is called

   A. wind vane
   B. rain gauge
   C. sunshine recorder
   D. Stevenson screen

B. Answer the following questions.

1. How do we receive weather information?

   _____
   _____

---

2. What is climograph?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Lesson 18: Weather Forecasting and Reporting

Welcome to Lesson 18. In our last lesson, we learnt how the weather can be represented on weather charts. We also learned that, the information on this charts can be used to forecast the type of weather of a place. In this lesson we will learn forecasting and reporting.

Your aims:

- state the importance of weather forecasting and reporting
- identify some traditional knowledge of predicting weather
- analyse a weather forecast from PNG National Weather Service
- state the importance of weather forecasts

Importance of Weather Forecasting and Reporting

There are many reasons why weather must be **forecasted*** and report every time. One of the many reasons is that, most of our daily activities depend on the type of weather we have at a particular time. For example, the crews of ships and airplanes need to know the type of weather a place has before setting off in that direction. Sports, fishing, hunting and gardening are some more examples which can be affected if weather is not favourable. In the past, our traditional elders used traditional knowledge to predict weather changes by observing the position at which the sun sets over the horizon over the land or sea. This can be useful to gardeners, fishermen and hunters.

Analysing Weather

Today, weather is reported to the public daily by newspapers, radio and television. For example, weather reporting in newspaper articles may look like the one shown below.

WEATHER (Information Supplied by the National Weather Service).

TODAY

PORT MORESBY:	Fine, Light NW wind. Temp 34^{o}C.
LAE:	Fine, Light NE wind. Temp 34^{o}C.
PNG COAST:	seas slight NW wind at 10 to 15 knots. Isolated showers.
PROVINCES: PAPUAN:	Generally fine. Light NW wind.
MAMOSE:	Fine part from a chance of a few afternoon showers. Light NW wind.
HIGHLANDS:	Morning fog then becoming fine. Light variable wind.
ISLANDS:	Generally fine. Light NW wind.
WARNING:	Nil.

YESTERDAY'S

PNG CENTRES: Daru 25, 32, 0; Goroka 17, 28, 9; Kavieng 24, 31, 3; Kerema 24, 33, 2; Kieta 23, 31, 0; Lae 26, 34, 0; Madang 24, 31, 18; Misima 25, 32, 0; Momote 25, 31, 2.4; Port Moresby 24, 34, 0; Rabau 23, 31, .8; Wewak 24, 31, 0.

WORLD CENTRES: Athens cloudy 6, 15; Auckland cloudy 17, 23; Bangkok clear 26, 33; Berlin cloudy 0, 5; Brussels clear -4, 6; Buenos Aires clear 19, 24; Cairo cloudy 16, 26; Christchurch cloudy 15, 19; Hongkong cloudy 16, 16; Honolulu clear 20,27; Jakarta clear 24,

33; Kuala Lumpur clear 24, 35; London cloudy 1, 6; Los Angeles cloudy 15, 0; Madrid clear -1, 7; Manila clear 21, 34; Moscow cloudy -10, -9; New Delhi clear 15, 27; New York clear -2, 3; Paris cloudy 1, 7: Rio de Janeiro clear 22, 36; Rome cloudy -2, 11; San Francisco rain 12, 36; Seoul cloudy -1, 06; Singapore cloudy 25, 33; Stockholm snow -3,0; Taipei cloudy 17, 25; Tokyo cloudy 4, 10; Toronto cloudy -5,-2; Wellington clear 17, 23.

Roles and Services of PNG National Weather Services (NWS)

The PNG NWS role is to collect and store weather information on daily maps. The information is then made available to airline pilots, newspapers, radio and television stations.

Traditional Ways to Predict the Weather

Is it just me or is the evening forecast becoming less and less reliable? No offense to weatherman but it just seems like the weather has a mind of it is own and it will never be controlled with computer predictions.

I have always been a big believer in the "crazy" weather prediction methods. I knew that if my grandma's knees hurt than we were in for some rain. And if the cattle started moving to a corner of the field you better be prepared to get indoors as fast as possible.
There are many methods for reading the sky, the animals, and our own bodies to help predict the weather and today you are going to learn all about them. Here's some ways that you can predict the weather forecast.

Cloud predictions:

- Cumulonimbus clouds (traditional thunderstorm looking clouds) early in the day and developing throughout the day can mean greater chances of severe weather.
- Mammatus cloud (the puffy, pocket looking clouds) can form with both severe and non-severe thunderstorms as well as other cloud types.
- Cirrus clouds (the stringy fluffy ones), high in the sky like long streamers, mean bad weather within the next 36 hours
- Altocumulus clouds, (look like fish scales), also "mean" bad weather within the next 36 hours. The sailor's saying is "Mares tails and mackerel scales, tall ships carry short sails." Rain is sure to follow the next day.
- Cumulus towers (look like an explosion in the sky) indicate the possibility of showers later in the day.
- Nimbostratus clouds (rain clouds) hang low and heavy in the sky, and mean rain is imminent.
- Cirrocumulus clouds (small, puffy in rows) means that cold weather is on it's way.
- The higher the clouds the fairer the weather.

The sky:

- If you see a red sky during sunset (when you're looking to the west), there is a high pressure system with dry air that is stirring dust particles in the air. This means dry air is moving towards you (no rain ahead but wind is sure to follow).

- A red sky in the morning (in the East, where the sun rises) means that the dry air has already moved past you, and what is behind it will now follow. (Rain or storm)
- Look for rainbows in the morning. A rainbow in the west means moisture is on its way, a rainbow in the east means the rain has left the area.
- If there is a ring around the moon at night, snow or rain will come in the next 3 days.

Smell:

- If you take a deep breath and smell earth and compost, moisture is coming soon.
- If flowers smell stronger than normal, rain is on its way.

Animals:

- If the birds are flying high in the sky, fair weather will stay around.
- If cattles seek a corner of a field or lie down in a group in the fields, a severe storm is immanent.
- Cats will clean their ears before a rain.
- Spiders come down from their webs before a rain.
- The louder the frogs, the more the rain.
- Ants will build their ant hills with steeper walls when rain is coming.
- When dogs eat grass, rain is coming.
- Bats flying around in the evening indicate fair weather.

Other:

- If there is dew in the grass in the morning, chances are it won't rain that day.
- If you make a fire outside and the smoke goes straight up, you will have good weather. If the smoke curls and wisps then a low pressure system (rain) is on its way).
- If it rains before seven, it will clear before eleven.
- If there is no dew for three nights, it will rain, you are sure to see.
- With dew before midnight, the next day sure will be bright.

Weather forecasts are predictions of what the weather will be like in an hour, tomorrow, or next week. Weather forecasting involves a combination of computer models, observations, and knowledge of trends and patterns. By using these methods, reasonable accurate forecasts can be made up to seven days in advance.

Accurate weather predictions are important for planning our day-to-day activities. Farmers need information to help them plan for the planting and harvesting of their crops. Airlines need to know about local weather conditions in order to schedule flights. Weather forecasting helps us to make more informed daily decisions, and may even help keep us out of danger.

Modern weather forecasting involves a combination of computer models, observation, and knowledge of trends and patterns. Using these methods, reasonably accurate forecasts can be made up to about five days in advance.

Beyond that, detailed forecasts are less useful, since atmospheric conditions such as temperature and wind direction are very complex.

Most of the computer models used for forecasting are run by the National Weather Service, which creates forecast models based on complex formulas. These models are used by many different weather and news services in preparing daily forecasts. Local weather observers, balloons, satellites, and weather stations also help provide data for forecasts.

You do not need to have a supercomputer or weather balloon to try your hand at forecasting, though. The most basic weather forecasting consists of simple observation. For example, you can look up at the clouds and try to recognize patterns as people did in the past. High, wispy clouds usually presage good weather. An overcast sky means rain or snow is on the way. Certain weather features seem to be associated with certain types of weather, at least most of the time.

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

1. Why is weather forecasting and reporting important?

   _____
   _____

---

2. How is the weather reported to the public daily?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 18.

Summary

You have come to the end of lesson 18. In this lesson you have learnt that:

- our daily activities depend on the type of weather we have at a particular time
- our traditional elders use traditional knowledge to predict weather in the past.
- weather is reported to the public by newspapers, radio and television
- PNG National Weather Services collects and stores weather data on daily basis. These data is then sent to pilots, newspapers, radio and television stations and ships.

NOW DO PRACTICE EXERCISE 18 ON THE NEXT PAGE.

Practice Exercise 18

Answer the following questions.

1. How did our traditional elders predict their weather in the past?

   _____
   _____
   _____

2. How are weather forecasts made?

   _____
   _____
   _____

3. What is a Stevenson Screen?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activity

1. It is important because most of our daily activities depend on the type of weather we have at a particular time. For example, the crews of ships and airplanes need to know the type of weather a place has before setting off in that direction.

2. Weather is reported by newspapers, radio and television.

Lesson 19: Climate

Well come again to Lesson 19. In our last lesson, we learnt about weather forecasting and reporting. We learned that the weather of an area can change.

Your aims:

- define climate
- discuss tropics, polar temperature regions and their climates
- discuss the type of winds in PNG
- state the importance of weather forecasts
- discuss weather and its effects

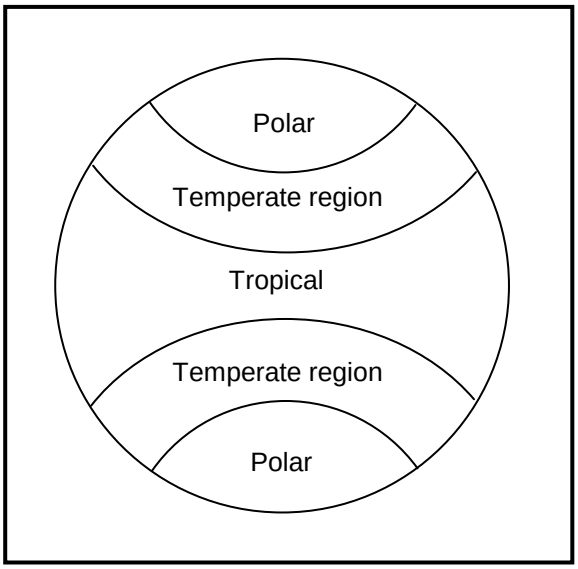
Climate in Papua New Guinea

The main variable of Papua New Guineas climate is not temperature or air pressure, but rainfall. The climate can be described as tropical climate, with the coastal plains averaging a temperature of 28°C, the inland and mountain areas averaging 26°C, and the higher mountain regions, 23°C. The area's **relative humidity*** is quite high, and ranges between 70 and 90 percent.

The **climate** in a region is the pattern of weather experienced over a period of time. It can also be described as the average weather conditions of a region.

Tropics, Temperate and Polar Regions

The world is divided into three main climatic regions with their own vegetation. The regions around the equator are called the **tropics**. The regions around the north and south poles are called the **polar**, and the areas in between the tropical and the polar regions are called the **temperate**.



The main climatic regions of the world

Polar and Temperate climates

These regions have noticeable changes in temperature and in the length of day and night during the year. These regions have four definite seasons called spring, summer, autumn and winter which occur in a regular cycle.

Spring is a season during which temperature rises, days get longer and nights get shorter.
Summer is a season straight after spring with the highest temperatures, longest days and shortest nights.
Autumn is the season during which the temperatures fall, days get shorter and nights longer.
Winter is the season with the lowest temperatures, shortest days and longer nights. The months of December, January and February are summer months in the **southern hemisphere*** and winter months in **northern hemisphere***. In June, July and August the seasons are reversed.

Activity: **Now test yourself by answering this activity**

Answer the following questions below.

1. What is meant by the term climate?

_____
_____
_____

2. What are the three main climatic regions of the world?

_____
_____

CHECK YOUR WORK. ANSWERS ARE AT THE END OFLESSON 19.

Tropical climate
In the tropical regions, temperature and length of days and nights do not change much throughout the year. This is because the tropics are close to the equator and are hardly affected by the tilt of the earth. Tropical region do not have the same seasons as the other regions. However, tropical regions do have wet and dry seasons that are caused by the winds from different directions. In between these two main seasons, is a shorter period of light variable winds called the **doldrums.**

Type of Winds in PNG

When the land masses are heated strongly in the southern hemisphere, low pressure areas are formed. This causes convection currents to be set up and the winds start to

blow from the north-west across the equator. This season is called the **north-west monsoons.**

However, in the middle of the year land masses in the north are heated strongly and hot air rises causing low pressure areas. The cool air from the south- east blow in across the equator. This season is called the **south-east trade winds.**

Weather and Its effects

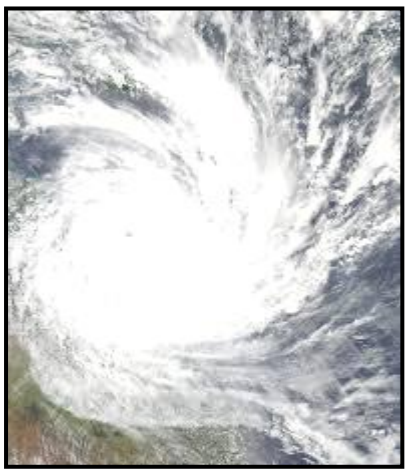
Weather affects the everyday lives of people in several ways. For example, the availability of food may be affected by too little or too much rain. The type and the amount of work people do may be determined by such things as the need for sunny weather to grow and dry crops, or the need to make sure that gardens are ready when the wet season begins.

On some occasions unusual weather causes severe damages to property, crops and livestock and human life. Climate change is real and is the greatest environmental challenge facing the world today with a complex manifestation in terms of its impacts on agriculture and food security. This can have a very serious effect on the way people live. In recent years, there have various communications on facts about climate change, how it is affecting PNG, and what interventions are needed to safeguard communities in the global warming scenario.

Some examples of unusual weather are:

1. **Cyclones**

   Cyclones develop from low pressure areas over the sea causing very strong winds and are accompanied by heavy rainfall. Below is an excerpt from the newspaper about a cyclone that occurred in Papua New Guinea.



PORT MORESBY, Papua New Guinea (The National, April 16, 2014) – More than 50,000 people in Milne Bay were badly affected when Cyclone Ita swept through the province, government officials say. Provincial disaster and emergency co-ordinator Eric Balaria said preliminary reports from outstations confirmed massive destruction to food gardens, homes and infrastructures. He said no lives were lost but 54,414 people were in need of assistance. The Category-Three cyclone later struck Northern Queensland in Australia causing millions of dollars of damage. Balaria said rural communities worst hit were Louisiade, Yeleamba and Bwanabwana in the Rossel and Sudest Islands in the Samarai-Murua electorate. People in the Murua local level government and Alotau escaped the full brunt of the cyclone. He said a preliminary survey revealed that 11,542 households were affected, 1,159 houses and 5,390 food gardens destroyed. Also destroyed were some classrooms, an aid post building and a VSAT communication system. Provincial disaster officials could not give the total estimated cost of the damage yesterday. Balaria said the full extent of the damage was likely to be known in the coming days when reports were received from many islands and locations still out of contact. "The cyclone caused extensive damage to properties, diplaced people, disrupted education of school kids and the normal life of people in the rural communities," he said. A report from Bwanabwana said the vessel mv Saga carrying 23 people was missing. "The immediate needs required by the population are food, water, shelter and medicine."Food gardens were destroyed by the flooding, landslides and severe winds in the remote islands. Shelter needs to be addressed in the small islands that felt the full blunt of the storm. "Increase in water-borne diseases and shortage of clean water require immediate attention."Balaria said food and water security were the two main term needs in the low lying islands and atolls in the affected zones.

Some of the damages caused by cyclone

2. **Floods**
   Floods are caused by heavy rains. Areas close to rivers are worst affected. Food gardens, houses, roads and bridges can all be destroyed by floods.

Floods in Papua New Guinea

Posted by Richard Davies on March 14, 2014
Some local media reports in Papua New Guinea are claiming that severe floods have affected over 10,000 people in West New Britain Province. According to the reports, houses in dozens of villages have been hit by the floods in West New Britain.

Flooding has also been reported in the West Mekeo area in Central Province. The floods are a result of constant heavy rainfall in the area over the last few days. The worst affected areas are Central and East Nakanai.

Flood in West New Britain

The Provincial Disaster Centre says that initial assessments show that bridges have been damaged or completely washed away. Culverts in Tiauru, Sege, Manari and Bala have also been badly damaged.

Roads have also suffered some damage, with parts of the Kimbe-Bialla Highway blocked and the main highway at Salelebu government station completely washed out. Blocked roads are likely to affect the areas of palm oil producers. Some of the affected areas are extremely remote, particularly villages in the region of the Luvi and Ala rivers.

Scene from Papua New Guinea's road conditions

Elsewhere in Papua New Guinea, heavy rains have resulted in the Angabanga River overflowing in the West Mekeo area in Central Province. The village of Gagaifua is said to have been completely washed away. No death has been reported. The village included around 17 houses, a church, school and store, as well as livestock and crops such as betel nut and banana. It was home to around 300 people, all of whom have now moved to higher ground.

1. **Drought**

A drought is a period of several weeks during which there is no rain and the soil loses all its moisture. There are claims in PNG for a major drought in 2012. This forecast was made several years ago by a senior scientist at the PNG National Agricultural Research Institute and has received much publicity in PNG.

The 1997 drought and frosts (at high altitude) caused great hardship for many rural villagers, with evidence of an increased death rate in a number of locations which had the greatest damage on villagers were characterised by remoteness, low cash income and limited ability of villagers to obtain cash with which they could buy imported rice and other food. The most immediate risk to PNG as a result of global climate change is the strong **El Niño- induced drought*.**

A drought tolerant cassava variety

Dry and cracked soil in a drought

2. **Frost**

Frost occurs when the moisture in the air turns to ice on the ground. Frost is a common problem in the Highlands at an altitude of 1500 meters and above. It can have serious effect on subsistence crops and cash crops.

The effect on the growth of the sweet potato causing it to grow more slowly and produce less and will not grow above 2800 metres is because of the low temperatures. In Highlands, the sweet potato is their staple crop.

The mentioned information on the previous page are all realities relating to climate change and its effects which are many and are beginning to affect us the Papua New Guineans. Our people are not aware of what is going on but are experiencing the effects of climate change but do not know the main contributing factor, what climate change is.

Sweet potato and choco fruit leaves damaged by frost

Summary

You have come to end of lesson 19. In this lesson you have learnt that:

- the climate of a region is the average weather that is experienced over a number of years.
- the earth has three climatic regions, polar, temperate and tropical regions.
- polar and temperate climates have four definite seasons called autumn, winter, spring and summer.
- cyclones, floods, droughts and frosts are all experienced in PNG.
- unusual weather can cause severe damage to property, crops, livestock and human life.
- weather affects the lives of people in several ways: the
  - availability of food,
  - type and the amount of work to be done,
  - type of houses to be built,
  - kind of clothes to be worn and
  - health of people.

NOW DO PRACTICE EXERCISE 19 ON THE NEXT PAGE.

Practice Exercise 19

Answer the following questions.

1. Describe the cause of north-west and south-east winds.

   _____
   _____

2. Differentiate the following seasons:
   a. Spring _____
   b. Summer _____
   c. Autumn _____
   d. Winter _____

3. What is a cyclone? How is it caused?

   _____
   _____

4. What causes floods? What kind of damage do they cause?

   _____
   _____

5. What is a drought?

   _____
   _____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF UNIT 6.

Answers to Activity

1. The climate of a region is the weather that is experienced by that region over a number of years.

2. The three main climatic regions are the tropical, temperate and the polar regions

Answers to Practice Exercises 14 - 19

Practice Exercise 14

1. i) orographic
   ii) convection

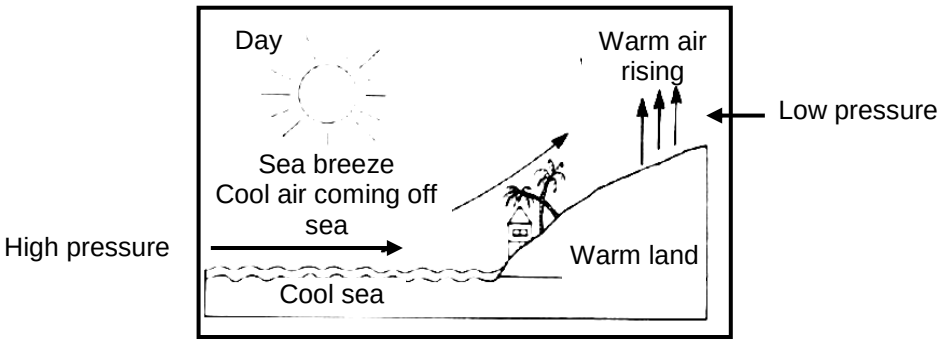
2. The circulation of air caused by the movement of hot / warm air

3. i) Land and Sea Breezes
   ii) Mountain and Valley breezes
   iii) Global Winds

4. i) Wind Speed - Anemometer
   ii) Wind Direction - Wind or weather vanes

5. i) Uneven heating of land and sea
   ii) Rotation of the earth

6. The flow of air, where cool air from the poles flow to replace the warm air from the tropics and equator, resulting in our global wind systems. At the same time rotation of the earth causes the heating of the earth's atmosphere at different times of the year giving rise to complicated world wind patterns.

7. 

Practice Exercise 15

1. Precipitation is the release of all water and solid water particles from the air.

2. i) orographic precipitation ii) convectional precipitation

3. i) rain ii) snow
   iii) dew iv) hail

   any of the above including frost

4. Orographic precipitation is caused by warm moist air from the coast been forced over the mountains, while Convectional precipitation is caused by warm air rising above the land.

5. The higher the altitude the cooler the air gets.

6. i.) Rain - it is the precipitation of liquid drops of water as rain drops.

   ii.) Snow - another form of precipitation where water vapour in the atmosphere has frozen into ice crystals and falls to the ground in the form of flakes.

   iii.) Hail - form of precipitation consisting of small balls of harden snow that falls has rain.

   iv.) Frost - when temperature is below freezing point, resulting in the deposit of ice crystals on the earth's surface.

Practice Exercise 16

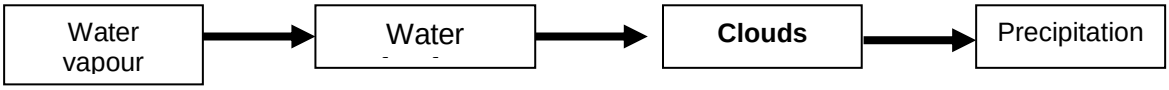
1. Clouds are made up of water vapour and forms when the air temperature or the air pressure drops.

2. 

   i) cirrus clouds

   ii) cumulus clouds

3. 

4.

Cloud Type	Description
stratus	forms a sheet over the sky
cumulus	looks like cotton wool
cirrus	high clouds.

5. Clear Sky

6. Cirrocumulus is high clouds, while stratocumulus is low clouds and altocumulus middle level clouds.

Practice Exercise 17

A.

1. **A**. climate

2. **B.** rain

3. **C**. temperature, rainfall, wind and evaporation

4. **C**. Outside and open area where the instruments will be fully exposed the weather.

5. **B**. rain gauge

B.

1. We receive weather information from different sources by telephone or radio at the National Weather Service at Jackson's Airport in POM.

2. It is the monthly temperature and precipitation of a certain place in the world at a given period of time.

Practice Exercise 18

1. Traditional elders use traditional knowledge to predict weather in the past.

2. Weather forecasts are made by studying weather records over the years and predicting the type of weather patterns.

3. A special box used to house the maximum and minimum thermometers.

Practice Exercise 19

1. When the land masses are heated strongly in the southern hemisphere, low pressure areas are formed. This causes convection currents to be set up and the winds start to blow from the north-west across the equator. Also, in the middle of the year land masses in the north are heated strongly and hot air rises causing low pressure areas. The cool air from the south-east blows in across the equator.

2. a. Spring is a season during which temperature rises, days get longer and nights get shorter
   b Summer is a season straight after spring with the highest temperatures, longest days and shortest nights.
   c. Autumn is the season during which the temperatures fall, days get shorter and nights longer.

d. Winter is the season with the lowest temperature, shortest days and longer nights.

3. A cyclone is a very strong wind accompanied by heavy rainfall. It is caused by low pressure areas above the sea.

4. Floods are caused by heavy rains. Areas close to rivers are worst affected. Food gardens, houses, roads and bridges can all be destroyed by floods.

5. A drought is a period of several weeks during which there is no rain and the soil loses all its moisture.

REVISE TOPIC 4 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 4: Weather

Now, revise all lessons in this Topic and then do **ASSIGNMENT 6.** Here are the main points to help you revise.

Lesson 14: Convection Current

- All air expands when heated.
- Warm air is less dense than cool air.
- Convection current is formed when less dense warm air is forced up by more dense cool air around it.
- The movement of cold high pressure air to replace warm low pressure air is called wind and is caused by the uneven heating of the earth's surface.
- Global wind patterns are affected by the rotation of the earth.
- Weather instruments such as the anemometer and wind vane measures the wind speed and direction respectively.

Lesson 15: The Properties of Air

- Precipitation is the release of all water and solid water particles from the air.
- Precipitation occurs when air can no longer hold its water.
- Pain, snow, hail, dew and frost are all different forms of precipitation.
- Orographic precipitation is caused by warm moist air from the coast been forced over the mountains.
- Convectional precipitation is caused by warm air rising above the land.

Lesson 16: Cloud and Cloud Types

- Clouds are made up of water vapour and forms when the air temperature or the air pressure drops.
- Before clouds are formed condensation must take place.
- There are three main types of clouds; cirrus- delicate white feathery clouds, cumulus – dense, white clouds with white flat base and stratus layered clouds.
- Cloud cover can be shown using symbols to indicate how much of the sky is covered and is often used to forecast weather.

Lesson 17: Weather Charts

- People who study weather are called meteorologists.
- A bar graph shows how much precipitation a given place receives during a period of time.
- A line graph shows the temperature for the same place during the same period of time.
- Weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity.
- Climograph shows the monthly temperature and precipitation of a certain place in the world at a given period of time.
- Weather instruments must be set up in an open area where they will be fully exposed to the weather.
- Weather station is a place where instruments are set up to measure the weather.

Lesson 18: Weather Forecasting and Reporting

- Our daily activities depend on the type of weather we have at a particular time
- Our traditional elders use traditional knowledge to predict weather in the past.
- Weather is reported to the public by newspapers, radio and television
- PNG National Weather Services collects and stores weather data on daily basis. These data is then sent to pilots, newspapers, radio and television stations and ships.

Lesson 19: Climate

- The climate of a region is the average weather that is experienced over a number of years.
- The earth has three climatic regions, polar, temperate and tropical regions.
- Polar and temperate climates have four definite seasons called autumn, winter, spring and summer.
- Cyclones, floods, droughts and frosts are all experienced in PNG.
- Unusual weather can cause severe damage to property, crops, livestock and human life.
- Weather affects the lives of people in several ways: the
    - availability of food,
    - type and the amount of work to be done,
    - type of houses to be built,
    - kind of clothes to be worn and
    - health of people.

NOW DO TOPIC TEST 4 IN YOUR ASSIGNMENT 6.

NOW YOU MUST COMPLETE ASSIGNMENT 6.

RETURN IT TO THE PROVINCIAL COORDINATOR.

GLOSSARY

A

Aerosol – sprayer, a liquid substance, as a disinfectant or deodorant, sealed in a metal container under pressure with an inert gas or other activating agent and released as a spray or foam through a push-button valve or nozzle

Asteroids - also called minor planets, any of the thousands of small bodies of from 480 miles (775 km) to less than one mile (1.6 km) in diameter that revolve about the sun in orbits lying mostly between those of Mars and Jupiter

Atmospheric circulation - any atmospheric flow used to refer to the general circulation of the Earth and regional movements of air around areas of high and low pressure

Atoms - the smallest components of an element having the chemical properties of the element, consisting of a nucleus containing combinations of neutrons and protons and one or more electrons bound to the nucleus by electrical attraction

B

Basalt **-** is the usually hard and black volcanic rock formed from (liquid) basaltic lava

Basaltic lava **-** contains less than about 52 percent silica (SiO2) by weight. Because of its low silica content, it has a low viscosity (resistance to flow)

C

Calcium carbonate - a white, crystalline, water-insoluble, tasteless powder, occurring in nature in various forms, as calcite, chalk, and limestone: used chiefly in dentifrices and polishes and in the manufacture of lime and cement

Climate zones - are the different geographical areas of the world that have a certain characteristic climate

Comets - celestial bodies moving about the sun, usually in a highly eccentric orbit, consisting of a central mass surrounded by an envelope of dust and gas that may form a tail that streams away from the sun.

Cosmic rays – high-speed particles--either an atomic nucleus or an electron--that travels throughout the Milky Way Galaxy, including the solar system

Crystals - clear, transparent minerals or glass resembling ice

D

Dynamo - an electric generator, especially for direct current**.**

E

Earth’s magnetism - also known as Earth's magnetic field is created by the rotation of its molten core

F

Forecasted **–** predicted, foreseen

G

Grains - the smallest possible amount of anything:

H

Hydrological cycle – also known as water cycle, describes the continuous movement of water on, above and below the surface of the Earth

M

Molecules - any very small particles

Molten - produced by melting and casting

P

Perpendicular – a straight line at an angle of 90 degrees to a given line, plane or surface

R

Radiates - to extend, spread, or move like rays from a center, to emit rays, as of light or heat

Radiative balance – radiation energy balance. The relationship between the amount of energy reaching an object and the amount leaving it.

Relative Humidity - the amount of water vapour in the air, expressed as a percentage of the maximum amount that the air could hold at the given temperature; the ratio of the actual water vapour pressure to the saturation vapour pressure

S

Satellites - a device designed to be launched into orbit around the earth, another planet, the sun.

Slab – a broad, flat, somewhat thick piece of stone, wood, or other solid material

Slam - a violent and noisy closing, dashing, or impact

Slopes - grounds that have natural incline, as the side of a hill

T

Tectonic plates – the dozen or so plates that make up the surface of the Earth. Their motion is studied in the field of plate tectonics

U

Ultraviolet radiation - radiation in the part of the electromagnetic spectrum where wavelengths are just shorter than those of ordinary, visible violet light but longer than those of x-rays

V

Velocity – the speed of something in a given direction

Viscous liquid – white, sticky liquid

Volatile - evaporating rapidly; passing off readily in the form of vapour

REFERENCES

Brandon Guymon, Written for the Kids Know It Network

Bunnet RB, General Georgraphy in Diagrams, 1997 Longman, Singapore

Davies Hugh, Earth Tok Earth Structure, Processes and Hazards from a Papua New Guinea Perspective. 1996, PNG Printing, Port Moresby

Geography4Kids.com | Physical Geography | Earth's Biosphere | Weathering

John Anderton and Papua New Guinea, Fundamental Science for Melanesia Book 4

Pople Stephen & Williams Michael, Science to GCSE, 2002 Oxford University Press, New York

Yahoo and Google

http://education.jlab.org/qa/matter_03.html

http://education-portal.com/academy/lesson/classification-of-of-igneous-rocks-textures-and-composition.html#lesson

http://form2notes.blogspot.com/2010/11/science-form-2-air-pressure.html

http://jersey.uoregon.edu/~mstrick/AskGeoMan/geoQuerry14.html

http://www.bbc.co.uk/bitesize/ks3/science/environment_earth_universe/rock_cycle/revision/4/

http://www.classzone.com/books/earth_science/terc/content/visualizations/es1201/

http://www.cliffsnotes.com/sciences/geology/weathering-and-erosion/processes-of-chemical-weathering

http://www.kidsgeo.com/geology-for-kids/0028-metamorphic-rocks.php

http://www.learner.org/interactives/rockcycle/diagram.html

http://www.lenntech.com/greenhouse-effect/fossil-fuels.htm#ixzz3154YEeTO

http://www.soest.hawaii.edu/GG/ASK/atmo-nitrogen.html

http://www.answers.com/topic/why-is-the-carbon-dioxide-in-our-atmosphere-so-important#ixzz30zzFUCFR

http://www.windows2universe.org/earth/geology/

http://www.soest.hawaii.edu/GG/ASK/atmo-nitrogen.html

FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
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12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
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14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General/Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics -General/Advance	Mathematics -General/Advance	Mathematics –General/Advance
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.