SAASTA AND SCOPEX TEACHER TRAINING

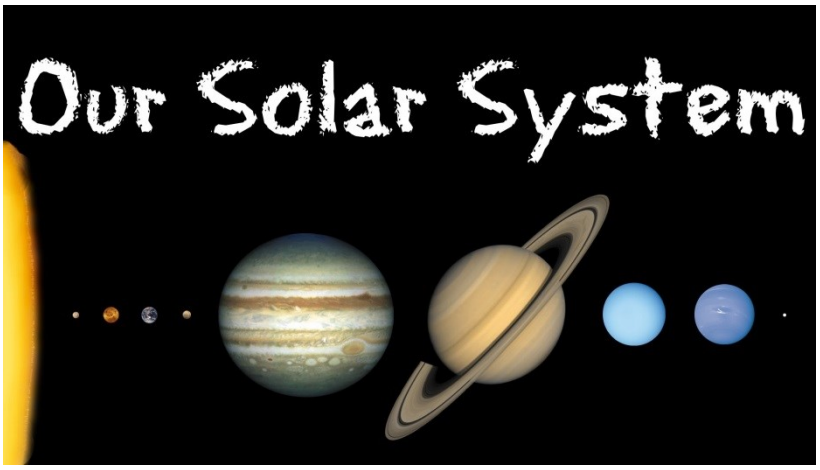
GRADE 8 TERM 4 TEACHER TRAINING MANUAL

Table of Contents

The Solar System

- The Solar system is a system of planets, dwarf planets, moons, asteroids, Kuiper Belt objects, comets and the Sun.
- The Sun, which is a star, is at the centre of the solar system.
- There are eight planets in orbit around the Sun, they are held in orbit by the Sun's gravity.

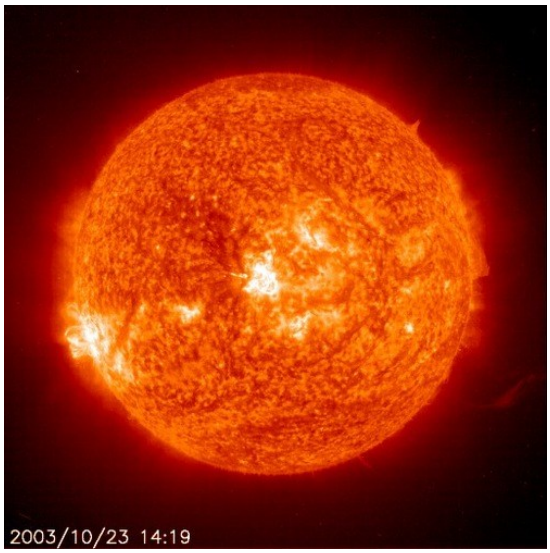
1. **M**ercury **(My)**
2. **V**enus **(Very)**
3. **E**arth **(Energitic)**
4. **M**ars **(Mother)**
5. **J**upiter **(Just)**
6. **S**aturn **(Served)**
7. **U**ranus **(Us)**
8. **N**eptune **(Noodles)**



- The Solar System looks like a flat disc or plate. The Sun rotates at the centre and the planets and all other objects orbit around it in the same direction.
- Gravity is the force that keeps all these objects in their stable, predictable orbits around the Sun.

The Sun

- The Sun is like all other stars – it produces large amounts of heat and light continuously.
- The Sun is by far the largest and most massive object in our solar system making up 98% of the total mass of the solar system.
- The energy in our Sun comes from powerful nuclear reactions during which hydrogen gas changes into helium gas.
- The Sun is 150 million km away from the Earth



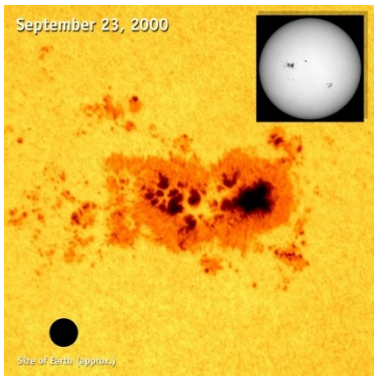
- The Sun is **mostly made up of hydrogen gas** (about 71%), and also helium gas (about 27%) with a tiny amount of other gases.
- The temperature at the Sun's surface is very high, around **5500 °C**.
- At the Sun's centre, or **core, it is about 15 million °C**. It is so hot at the Sun's centre that **nuclear reactions** occur, which change atoms from one element to another.
- In the Sun's case, four hydrogen nuclei are squeezed or fused together to form a new helium nucleus. This process is called **nuclear fusion**.
- This nuclear fusion reaction releases energy because the new helium nuclei produced have very slightly less mass than the four hydrogen nuclei used to make them.
- How can this be? Well, according to the famous scientist Albert Einstein, **energy and mass are equivalent.**

$$E = mc^2$$

- Some of the mass in the hydrogen nuclei is converted and released as energy when the nuclei fuse to make helium.
- The outer atmosphere of the Sun is called the **corona and it is a million °C hot**.
- Gas particles from the corona are constantly escaping into space, forming the **solar wind**.
- When the Sun is very active, violent eruptions called **solar flares** occur on its surface.
- **Sunspots** are areas that are slightly cooler, and therefore darker, than the rest of the Sun's surface.
- A typical sunspot only lasts a few days.
- The sunspot appears to move across the Sun because the Sun is spinning slowly on its own axis.

The diameter of the sun is 109 bigger than that of the Earth's

The volume of the Sun is a million times larger than the Earth's



Sunspot.

For perspective, take note of the size of the Earth in the lower left.

Interesting videos

- https://youtu.be/Ux33-5k8cjg
- https://youtu.be/ha-9x6lVAE4
- https://youtu.be/3Ghaf2du-XM

Objects around the Sun

- Each planet has its own features, size, composition, surface temperature, orbit and position in relation to the Sun, number of moons and revolution around the Sun.
- The **Kuiper Belt** is a disk-shaped region past the orbit of Neptune containing many small icy bodies. It is considered to be the source of the **short-period comets**.
- This region is home also to the dwarf planets such as **Pluto**, **Eris**, **Haumea**, **Makemake** and **Ceres.**
- The **Oort Cloud** is an extended shell of icy objects that exist in the outermost reaches of the solar system and is thought to be the origin of most of the **long-period comets** that have been observed.
- The four planets closest to the Sun are Mercury, Venus, Earth and Mars are called **terrestrial planets** because they have solid rocky surfaces.
- The last four planets Jupiter, Saturn, Uranus, and Neptune are called **gas giants**. These are much larger than the terrestrial planets and are mainly made of gas with small cores of rocky materials.
- In between the terrestrial planets and the gas giants lies the **asteroid belt** and out beyond the orbit of Neptune lies the **Kuiper belt.**
- Gravity is the force that keeps all these objects in their stable, predictable orbits around the Sun.

Definition of a planet

1. Orbit around the Sun.
2. Be large enough that its own gravity pulls it into a spherical shape.
3. Clear out smaller objects in its orbit, by either flinging them into another orbit or by attracting and then sticking them to itself (this means that there are no other similar sized objects orbiting in their vicinity).

Definition 3 is the reason Pluto was reclassified from a Planet to a dwarf planet in 2006.

Activity: The scale of the solar system

To get a better feel for the solar system we can build a model. The best model shows the relative size and distance of each planet to the Sun. This, however, is very difficult as a big area is needed to accomplish this. For instance, if we reduce the size of the Earth to a pinhead, the distance of Pluto from the Sun would be about 170m away.

It is therefore best to make two separate models, one to illustrate the relative planetary distances from the Sun and one to illustrate the relative sizes.

Relative Sizes

Materials:

- Drawing compass
- Construction paper
- Scissors
- Colourful markers

Method:

Cut out circles of the following sizes

Planet	Scaled Planet size (cm)
Mercury	1
Venus	2.5
Earth	2.5
Mars	1.3
Jupiter	28
Saturn	25
Uranus	10
Neptune	9
Pluto	0.5

If you want to include a Sun cut out in the same scale, the disk will need to be 2795 cm.

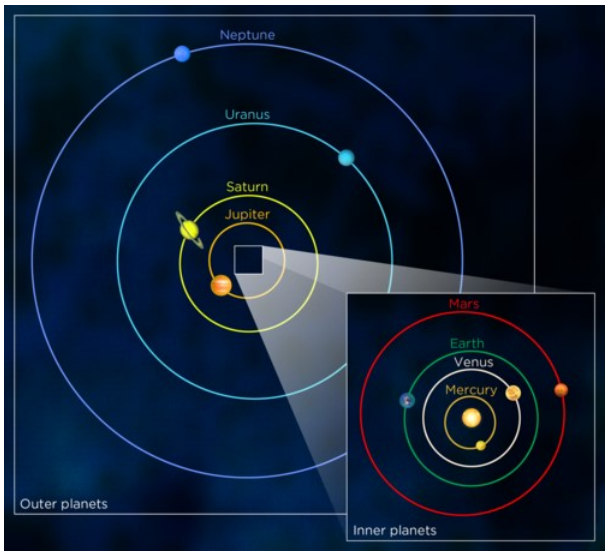
Relative Distance

To enable this activity to be done in class we are basing our measurement of a Sun the size of a 'full stop'.

Planet	Scaled Distance between each planet and the Sun (cm)
Mercury	4
Venus	7.7
Earth	11
Mars	16
Jupiter	56

Saturn	1
Uranus	2
Neptune	3.2
Pluto	4.2

This activity combines both size and distance into one model.



The orbits and planets in the solar system which we are going to model.

Materials:

- grapefruit
- peppercorns
- salt grains
- poppy seeds
- pea
- grape
- measuring tape

Instructions:

1. Go outside to a large field for this activity. Start at one end of the field.
2. Put the grapefruit on the ground, this represents the Sun.
3. Measure 4.2 m away from the grapefruit and put a grain of salt on the ground. This represents Mercury. If you do not have a measuring tape then count four big strides away from the Sun instead.
4. Repeat this for each of the planets in the solar system. Your teacher will tell you the distance each planet lies from the Sun and will give you the appropriate object to represent your planet.
5. Guess how far away you think the next closest star after the Sun is.

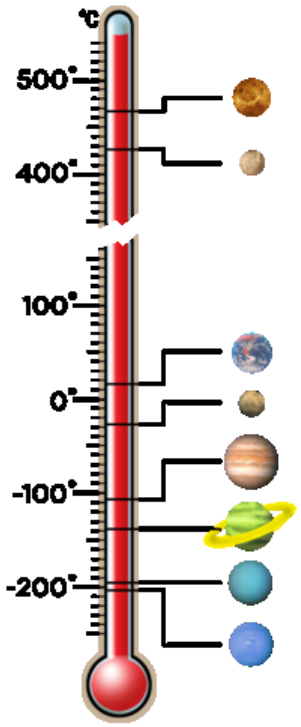
Earth's position in the Solar System

- The Earth is the third planet from the Sun the Earth is the only planet that is known to support life.
- The conditions that support life on Earth include:
    - Temperature: Earth's distance from the Sun provides the ideal temperature range
    - Water is a gas, liquid or gas in Earth's temperature rang
    - Sunlight provides the energy in the food chain

Activity: Planetary Temperatures

Instructions:

1. Look at the table, it shows the surface temperatures of each of the planets.
2. Correctly label each of the planets on the thermometer using the temperature information provided in the table.



Planet	Temperature (°C)
Mercury	167
Venus	464
Earth	15
Mars	-65
Jupiter	-110
Saturn	-140
Uranus	-195
Neptune	-200

Questions:

1. Which planet has the lowest average temperature?

   _____

2. Why do you think this is?

   _____

3. What do you notice about the average temperatures of the terrestrial planets compared with the gas giants?

   _____

4. If you exclude Venus, how does the ordering of the planets from the Sun compare with their average temperature?

   _____

This NASA page will help with more information
http://solarsystem.nasa.gov/kids/index.cfm?Filename=homework&Target=SolarSys#

Activity: Planet fact sheet

In this activity you will make a one page fact sheet about your chosen planet.

Materials:

- information about the planets
- pictures of the planets

Instructions:

1. Research information about your chosen planet.
2. Write a one page fact sheet about your chosen planet.

Activity: The Sun's Habitable Zone

Property	Venus	Earth	Mars
Distance from Sun (AU)	0.7	1	1.5
Average Temperature (°C)	464	15	-65

Materials:

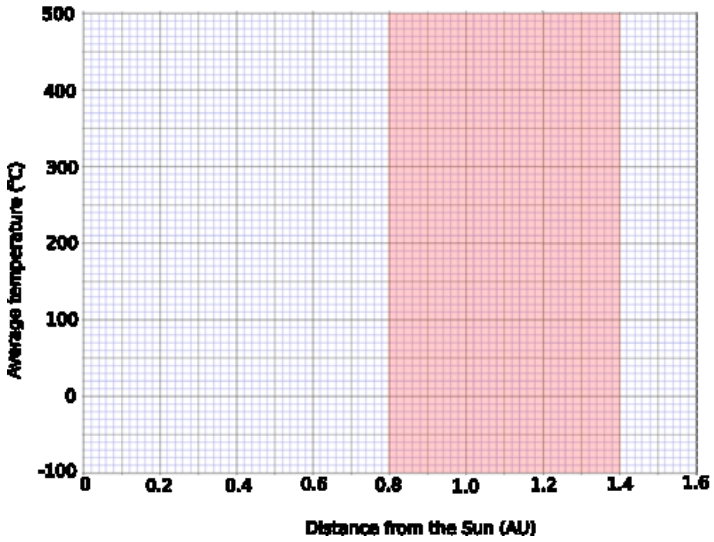
- pencil
- ruler

Instructions:

1. Look at the data provided in the table. It shows the distance from the Sun for three planets (in units of one Earth-Sun distance or Astronomical Unit). It also shows the average temperature on each planet in degrees Celsius.

2. Plot a graph to show the data in the table. Mark each point with an X.
3. The Sun's habitable zone extends from 0.8 to 1.4 AU and is shaded in red in the graph paper. This is the region where scientists think a planet has to lie in order for there to be life on the planet.

<u>Graph showing the average temperature and the distance from the Sun of Venus, Earth and Mars.</u>



Questions:

1. What is the average temperature on Venus?

   _____

2. Can liquid water exist on Venus? Why?

   _____

3. What is the average temperature on Mars?

   _____

4. Is liquid water likely to be found on Mars? Why?

   _____

5. What is the average temperature on Earth?

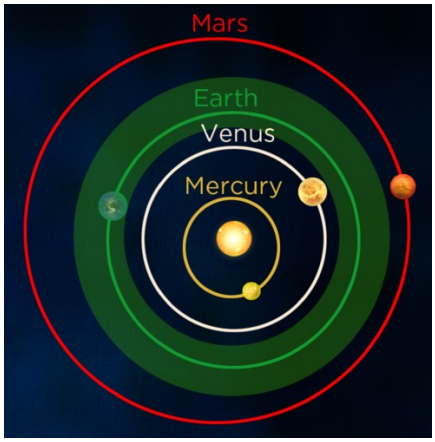
   _____

6. Can liquid water exist on Earth? Why?

   _____

7. Which planet/s lie within the Sun's habitable zone (the red shaded region in the graph)?

   _____



*Our Sun's **habitable zone** lays between 0.8 - 1.4 (AU)*

Water can exist as liquid, which is essential to life, in this zone

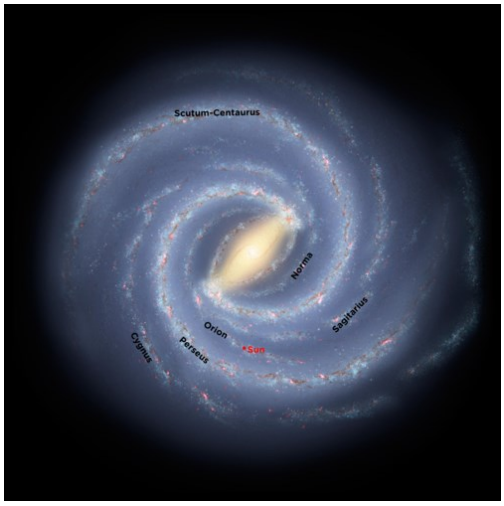
The Milky Way Galaxy

- Our Solar System is in the Milky Way Galaxy
- A galaxy is a collection of millions upon millions of stars held together by their mutual gravity
- Our Sun is only one of about 200 billion stars in the Milky Way Galaxy
- The Milky Way Galaxy is about 100 000 light years across
- The Milky Way Galaxy is in the shape of a spiral with many arms
- Our Sun is located towards the edge of the Milky Way Galaxy in one of the spiral arms
- From the Earth, looking towards the centre of the Milky Way Galaxy, we see a hazy path of light across the sky

The Milky Way stretching across the sky viewed from Sutherland.

If you could travel outside the Milky Way and look down on it from above, the galaxy would look like a giant spiral in space as shown in the following image.

Scientists think that there are five major spiral arms in our galaxy. These are the Norma Arm, the Scutum-Crux Arm, the Sagittarius Arm, the Perseus Arm and the Cygnus Arm.
Our Sun is located in a small spiral arm called the **Orion (or Local) Arm** which lies between the Sagittarius Arm and the Perseus Arm. It takes about 225 million years for the Sun to make one complete orbit around the Milky Way Galaxy.



Activity: Draw the Milky Way

Materials:

- black paper
- white crayon, pencil or paint
- glue - optional
- glitter or sand - optional
- newspaper for working on
- white or silver pencil/pen for labelling
- sticker - optional

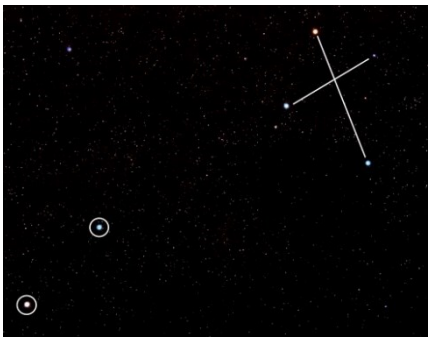
Instructions:

1. Draw or paint a picture of the Milky Way. You can use the picture in the text above as a guide. The galaxy has five major spiral arms, and some smaller ones including our Orion Arm. The galaxy also has a bulge in the middle.
2. If you are going to use glitter or sand, glue along your spiral arms and in the central bulge.
3. Scatter glitter or sand over the picture, each grain represents a star in our Milky Way.
4. Tilt the picture onto the newspaper to remove any excess glitter.
5. Label each of the major arms of the Milky Way Galaxy.
6. On the Orion Arm place a sticker or mark a point halfway out from the galaxy centre. This marks the position of the Sun.

Our nearest star

- The Sun is our closest star, and is *only* 150 million kilometres from Earth.
- A **constellation** is a group of stars that, when viewed from Earth, form a pattern in the sky.
- One famous constellation that is visible, even from big cities in South Africa, is the **Southern Cross or Crux**. The two bright stars at the bottom left pointing towards the cross are called **the Pointers**.
- The brightest of the Pointers looks slightly orange if you look closely. This star is called **Alpha Centauri** and is our closest easily visible star after the Sun.

- Alpha Centauri is actually part of a triple star system which is where three stars are in orbit around each other. The two main stars of the system are called Alpha Centauri A and Alpha Centauri B. A smaller, fainter star, called **Proxima Centauri**, orbits much farther out



The Pointers (circled) and the Southern Cross.

- Alpha Centauri is 4,2 light years away from our Solar System

Light years, light hours and light minutes

Alpha Centauri A and B are 42 trillion km away from us. These numbers are astronomically large! As the numbers are so large, astronomers do not use kilometres to measure the distances to stars, but use larger units based on the speed of light called the **Light Year.**

- **A light year is the distance that light travels in one year**
- **One light year is about 10 trillion km**
- A light hour is the distance that light travels in one hour
- Our Solar System has a diameter of about 13 light hours
- A light minute is the distance that light travels in one minute
- The Earth is about 8 light minutes away from the Sun

Activity: Speed of light

Find out the top speeds the following can reach:

Cheetah

Peregrine Falcon

Japan's high speed train the JR-Maglev MLX01

NASA's scramjet the X-43

The international space station (ISS)

Now compare these speeds to the speed of light at about 1080 million km/h, or 300 000 km/s $(3x10^8\ m/s)$.

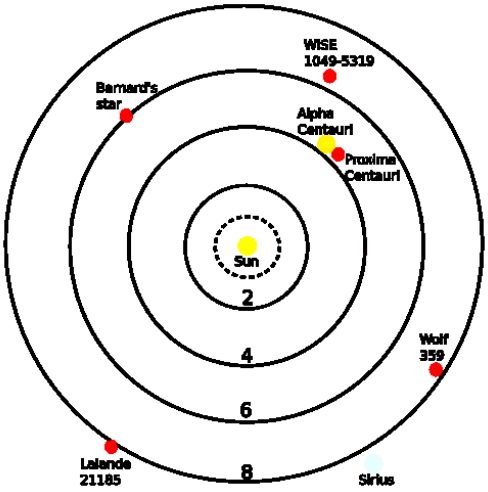
In one second light can travel…	Light takes…
Between Cape Town and Johannesburg 214 times.	0.0000003 seconds to travel 100 m.
Between Cape Town and London, England, 31 times.	1.3 seconds to travel from the Earth to the Moon.
Around the Earth 7.5 times.	8 minutes to travel from the Sun to the Earth.

Instructions:

1. Imagine you are going on a trip from Cape Town to Durban, which is a distance of 1753 km.
2. Calculate how long it would take you to complete the trip travelling at the speeds of the animals and modes of transport in the examples above.
3. Fill in your answers in the table below.

Remember the formula *time = distance / speed*

Mode of transport	Speed (km/h)	Distance between Cape Town and Durban (km)	Time taken for the journey
Cheetah	120	1753	14.6 hrs
Peregrine falcon		1753	_____hrs
High speed train		1753	_____hrs
NASA's scramjet		1753	_____mins
ISS		1753	_____sec
Light		1753	_____sec



The following map shows the Sun in the centre with the locations of our closest stars. Each solid ring represents a distance of 2, 4, 6 and 8 light years from the Sun. The dotted circle represents the Oort Cloud.

Questions:

1. Which star is our closest neighbour, excluding the Sun?

   _____

2. How far is Sirius?

   _____

3. How long does light from Barnard's Star take to reach us?

   _____

4. Explain in your own words what the statement "Sirius is 8.58 light years away from Earth" means.

   _____

Beyond the Milky Way Galaxy

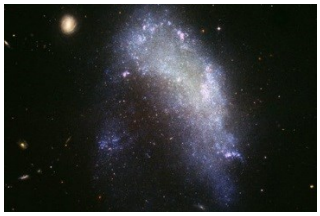
- Our Milky Way Galaxy is only **one of billions of galaxies scattered across the Universe**.
- The diameter of the observable Universe is estimated to be about 93 billion light years, putting the edge of the Universe at about 46 billion light years away.
- Galaxies have various shapes and sizes.
- As well as stars, galaxies contain vast amounts of gas and dust.
- Our closest galaxy neighbour is called the **Andromeda Galaxy**. Andromeda is 2.5 *million* light years away from the Milky Way.
- If you wanted to travel to Andromeda and could travel as fast as light, it would still take you 2.5 million years to get there.
- There are five main types of galaxies.
    - **Spiral, Barred spiral, Elliptical, Lenticular, Irregular**

Spiral galaxy, NGC 4414

Barred spiral galaxy, NGC 1300

Elliptical galaxy, NGC 1132

Lenticular galaxy, NGC 5866



Irregular galaxy named NGC 1427A

Interesting Videos

https://youtu.be/Rj1sDWjvgjM(How far is a light year?); *https://youtu.be/nrTsvn9usVQ* (What is the Universe); *https://youtu.be/5NU2t5zlxQQ(*How big is the Universe?); *https://youtu.be/UE8yHySiJ4A*(Largest Universe); *https://youtu.be/bENTuGmw0Sg* (How do we know how many galaxies there are in the Universe?)

Early viewing of space

- People can see planets and stars in the night sky
- Stars can be arranged into visible **constellations**
- Different cultures have identified and named certain constellations
- Some constellations have stories linked to them (different cultures have different stories)
- Early cultures noted the movement of the stars and planets across the sky and used this to mark the passage of time (They could tell different seasons and activities and also navigation)
- **The stars that are visible depend upon your location on Earth and also the time of year**.
- The southern sky, which we see from South Africa, is full of beautiful stars and several prominent constellations are visible in the sky including the **Southern Cross or Crux, Orion, Carina, Centaurus.**
- There are more constellations visible from the Southern Hemisphere because the South Pole faces the centre of the galaxy and, therefore, more stars.

The Orion Constellation, seen here as the three bright stars in the middle making up Orion's belt and the 4 stars in each corner.

You might imagine that all the stars lie at the same distance from Earth. This isn't true, the **stars lie at different distances.** The closest star in Orion is called Bellatrix and is around 250 light years away. The furthest star Meissa is around 1100 light years away, roughly the same distance as the Orion nebula (1300 light years). But, when viewed from Earth, we see them making up a pattern in relation to each other.

Activity: Constellation starlore

The /Xam Bushman imaged that the two pointer stars of the Southern Cross were two male lions who had once been men before they were thrown up into the sky to be stars by a magical girl. The three brightest stars in the Southern Cross were seen as female lions, perhaps women also changed into stars by the magical girl.

The Khoikhoi thought that the Pointers were the eyes of some great beast and they were called *Mura* which means *the eyes*.

In Sotho, Tswana and Venda cultures, these stars are called *Dithutlwa* which means *the Giraffes*. The bright stars of the Southern Cross are male giraffes, and the two Pointer stars are female giraffes. The Venda named the fainter stars of the Southern Cross *Thudana*, which means *the Little Giraffe*. The Sotho used these stars to indicate the beginning of the cultivating season which began when the giraffe stars were seen close to the south-western horizon just after sunset.

Instructions:

1. Search for a story about a constellation found in the South African sky.
2. Use a South African star map as a guide to the constellations found in South Africa.
3. Research information on the origin of the story and any beliefs associated with it.
4. Your teacher will decide on the format of this presentation which might be a poster or oral presentation.

Interesting Videos

http://www.psychohistorian.org/display_article.php?id=200901111733_african_star_lore.content(traditional African starlore);
http://www.beforebc.de/AfricanaResources/AfricanaResources/AfricanStarlore.html and
http://www.rmg.co.uk/explore/astronomy-and-time/astronomy-facts/stars/south-african-star-myths (South African starlore)

Telescopes

- People can see more details in the sky when they use a telescope
- **A telescope forms an image of the object and magnifies it**
- There are different types of telescopes including:
    - **Optical telescopes** receive light and focus it by **refraction (using lenses)** or **reflection (using mirrors)** such as **SALT** (Southern Africa Large Telescope), and the Hubble Space telescope
    - **Radio telescopes** receive radio waves and focus them by reflection (typically using a metal receiving dish) such as the **SKA** (Square Kilometre Array)

- Good conditions for looking into space include cloudless skies with limited light and air pollution

The Andromeda galaxy, viewed with the Hubble Space Telescope. Humans can only see it as a tiny faint smudge in the sky with the naked eye.

Unfortunately, we cannot visit distant stars or galaxies to study them directly as they are so far away. Instead **astronomers study stars and galaxies by analysing the visible light, radio waves and electromagnetic radiation that they receive from them**. Human eyes can see very far. The Andromeda Galaxy which is 2.5 million light-years away is visible to the naked eye. However, we cannot make out any detail as it appears as only a tiny smudge on the sky to our eyes even though in reality it is 220 000 light years across.

Let us take a brief look at the different types of telescopes, namely:

- **Optical telescopes**
- **Radio telescopes**
- **Space telescopes**

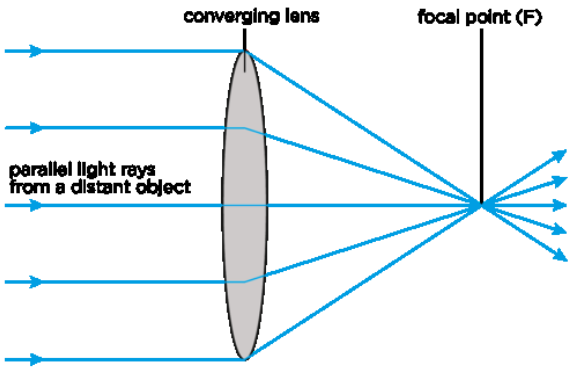
Optical telescopes

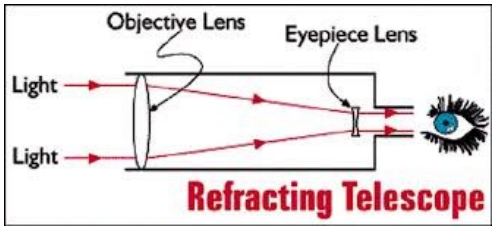
There are two types of optical telescopes;

1. **Refracting** telescopes use **lenses** to collect and focus the light from distant objects.
2. **Reflecting** telescopes use **mirrors** to collect and focus the light from distant objects.

Refracting telescopes

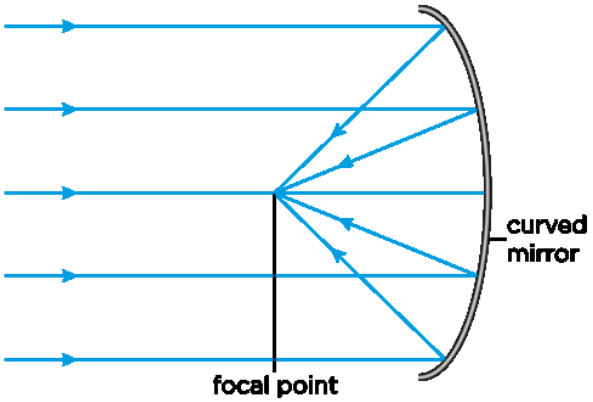
Refracting telescopes use a converging (convex) lens to collect and bend the light rays inwards to the focal point (also called the focus) of the telescope. The light collecting lens is called the objective lens.

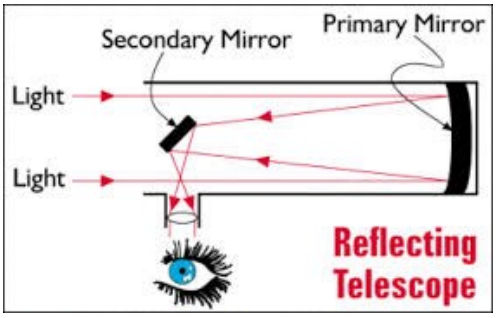




Reflecting telescopes

In the 1680s, Isaac Newton invented the reflecting telescope. Reflecting telescopes use a curved primary mirror to collect light from distant objects and reflect it to a focus.

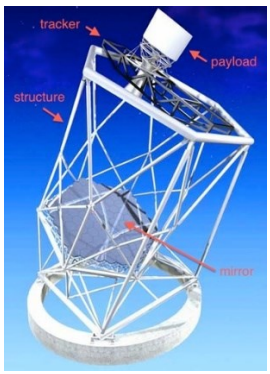




SALT

- **The Southern African Large Telescope (SALT)** is the largest optical telescope in the southern hemisphere and among the largest in the world.
- SALT was completed in 2005 and is located in the Karoo in the Northern Cape, near the town, Sutherland. Astronomers use telescopes like SALT to study planets, stars and galaxies.
- SALT can detect the light from faint or distant objects in the Universe a billion times too faint to be seen with the naked eye.
- The whole telescope structure weighs 85 tons.
- The **payload** contains trackers and detectors which take pictures of the night sky.
- The Karoo is an ideal place to host SALT because it is far away from towns and cities so there is very little light pollution. The area is also at a high elevation

The SALT telescope has a large mirror which collects light. SALT's primary mirror is a hexagonal shape measuring 11.1 m by 9.8 m across and is made up of 91 individual 1.2 m hexagonal mirrors. SALT is a prime focus reflector.



Interesting Videos

https://youtu.be/PkQbkuansGg (The Southern African Large Telescope); https://youtu.be/GziHcbBhSHo (The atmosphere and optical telescopes); https://youtu.be/m9QcQGoOjbI (How telescopes work); https://youtu.be/fmTioY_b-sY (History of telescopes); https://youtu.be/msIAdyljrwI (How to make a small, easy telescope)

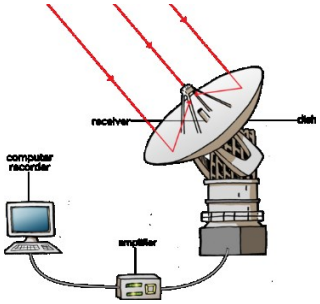
Radio telescopes

One of the SKA dishes

- **Radio waves are a type of electromagnetic radiation (or light)** that humans cannot see with their eyes. They have very long wavelengths compared to optical light.
- Purple light, for example, has a wavelength of 400 nm whereas red light has a wavelength of 700 nm.
- Radio wavelengths are much longer; radio waves have wavelengths from approximately one millimetre to hundreds of metres.
- **The Square Kilometre Array (SKA)** will be the most powerful telescope ever
- It will have a total collecting area of **one square kilometre**.
- It will have 3000 radio dishes each about 15 m wide which will act together as one large telescope.

Many different countries are working together to build, and pay for, the SKA. Most of the SKA will be located in South Africa. There will also be locations in Australia and some stations in eight African partner countries.

Radio telescopes typically look like large dishes. The **dish** or **antenna**, acts like the primary mirror in a reflecting telescope, collecting the radio waves and reflecting them up to a smaller mirror which then reflects the radio waves to a radio wave detector. Radio wave detectors are called **receivers**. An **amplifier** amplifies the signal and sends it to a computer which processes the information from the receiver to create colour images which we can see.



Interesting Videos

https://youtu.be/cXOzAcWS8yY (What is a radio telescope?); https://youtu.be/0mfXKXVWG1s (A video on the SKA); http://www.ska.ac.za/

Space telescopes

The Hubble Space Telescope has a 2.4m diameter collecting mirror.

Radio waves and visible light form part of what is called the **electromagnetic spectrum of light**. There are other types of light at different wavelengths that we cannot see with our eyes including **X-rays, ultraviolet and infrared light.**

The Earth's atmosphere blocks X-rays, ultraviolet and infrared light and stops them from reaching the ground. So if we want to observe this kind of light from stars and galaxies, we need to put telescopes in space. This is why X-ray telescopes and infrared telescopes are placed in space.

- The advantages of space telescopes are that they can observe the whole sky and operate during both night and day.

- Images taken with space telescopes are far sharper than images taken with telescopes on the ground, because images are not smeared or blurred by turbulence in the Earth's atmosphere, as with images take from ground telescopes.
- This is why the Hubble Space Telescope images are so detailed even though it is a relatively small reflective telescope.
- The major disadvantages of space telescopes are their costs and the fact that if something goes wrong they are extremely difficult to fix.
- NASA is currently planning the successor for the Hubble Space Telescope, called the James Webb Space Telescope (JWST). It will be launched into space in 2018.

Interesting Videos

https://youtu.be/--X9zfgZtS0 (The Hubble Space Telescope); https://youtu.be/z_ISPDTpJrk (The best of Hubble); https://youtu.be/QMRamEFAQU4 (More about the James Webb Space telescope)