Theme 4
Earth and Space Exploration

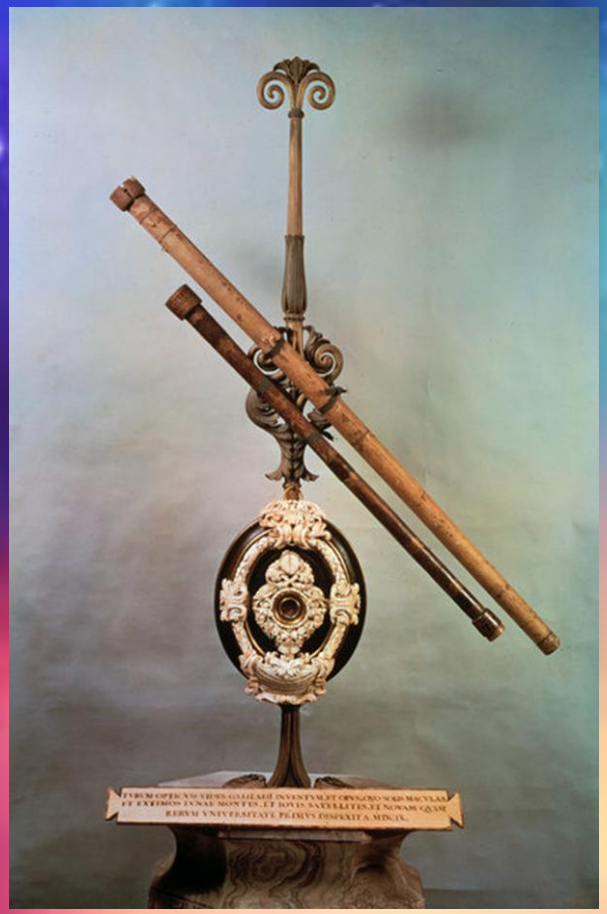
Chapter 11: Star and Galaxies in the Universe

Astronomy

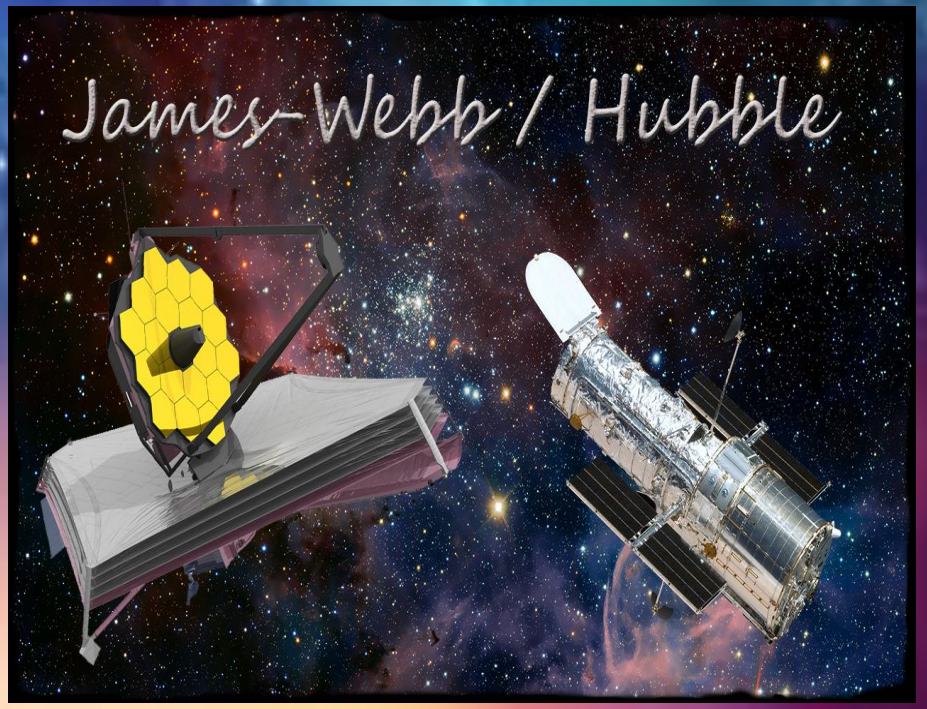
- The scientific investigation on all objects in the universe
- Oldest fields in science
- Invention of telescopes has enabled scientists to investigate the objects in space in great detail

First telescopes

- Galileo Galilei's refracting telescope
- 1609



- Hubble Space Telescope
- James Webb Space Telescope
- Enable scientists to explore deep space



Launched on the 24 April 1990

Starting from 2018

- Radio telescopes with parabolically-shaped dish help scientists to detect any radio-frequency radiation from space

11.1 .1 Galaxies

What do galaxies mean?

A galaxy is a set of bodies consisting of stars with gas and dust particles

There are millions of galaxies in the universe.

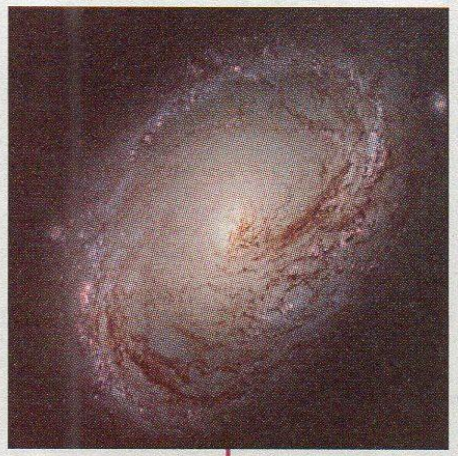
Galaxies are classified based on their shape.

Types of galaxies

Spiral

Examples:
Andromeda and
The Milky Way

Elliptical



Examples:
Ursa Major and
Messier 87

Irregular

Examples:
Small Magellanic
Cloud and Large
Magellanic Cloud

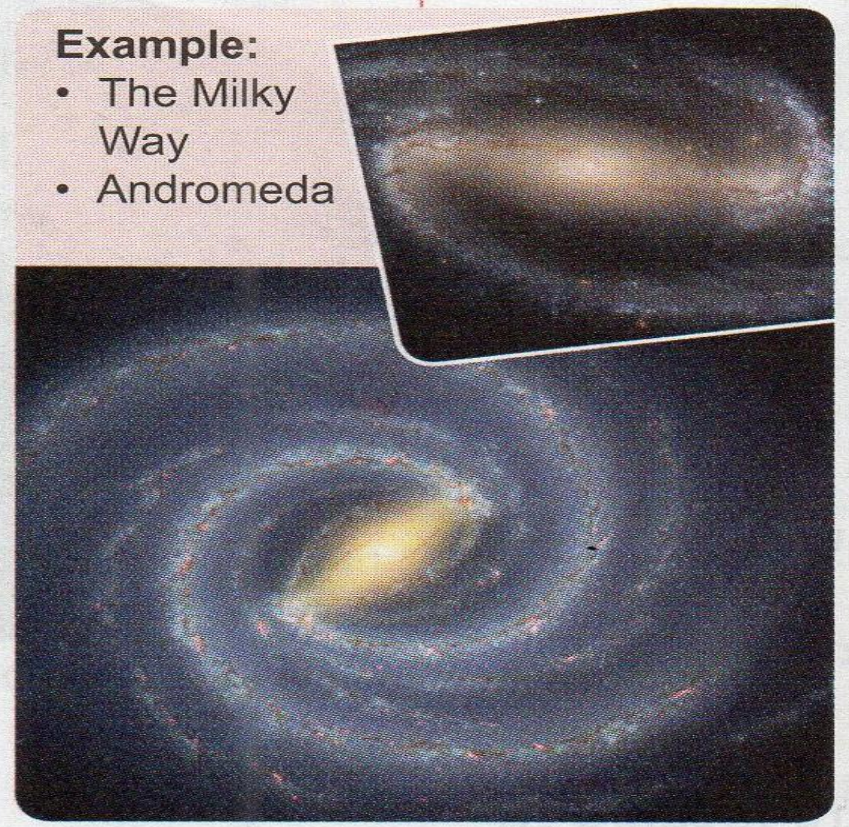
Photograph 11.2 *Types of galaxies*

Spiral galaxy

- **Disc**-shaped with **spiral arms**
- Consists of old dimmer stars at its centre and **young hot stars** at the arms
- **Brighter** than other types of galaxy
- Normally larger than elliptical and irregular galaxies

Example:

- The Milky Way
- Andromeda



Elliptical galaxy

- **Oval** (elliptical) or **round** shaped
- Consists of old and **dimmer** yellow stars
- Lower temperature
- Contains subtle gas or dust
- Normally smaller than spiral and irregular galaxies

Example:

- Messier 87 at the centre of Virgo cluster
- Leo I in the Local Group

Irregular galaxy

- *No* definite pattern or shape
- Consists of **young stars**
- Normally larger than elliptical galaxies but smaller than spiral galaxies

Example:

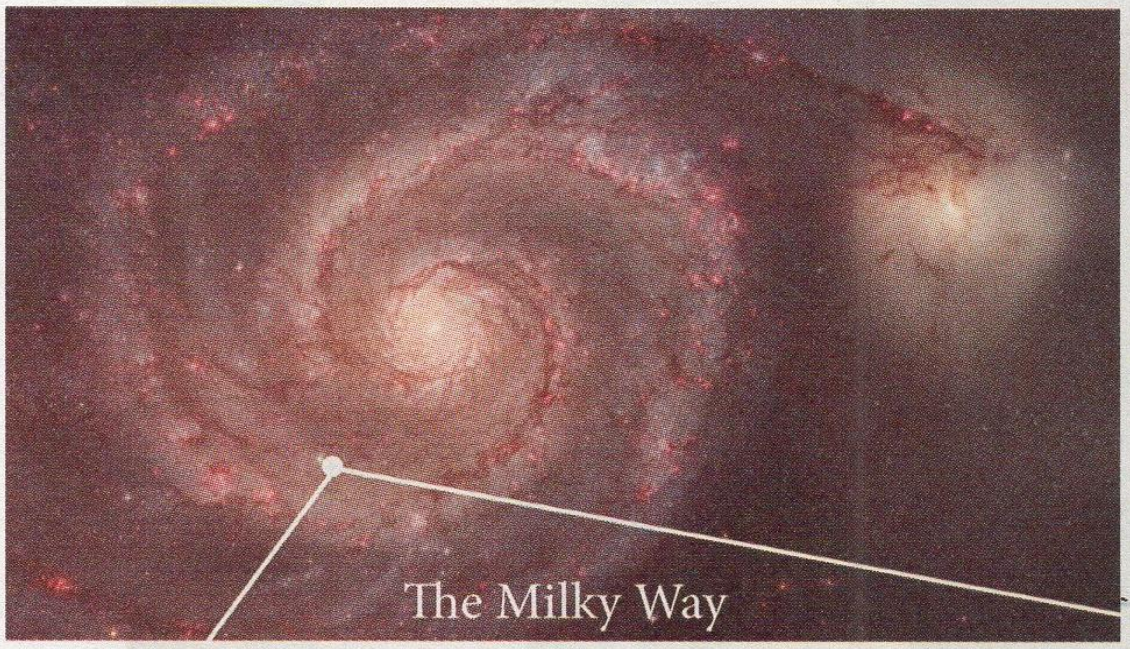
- Large Magellanic Cloud

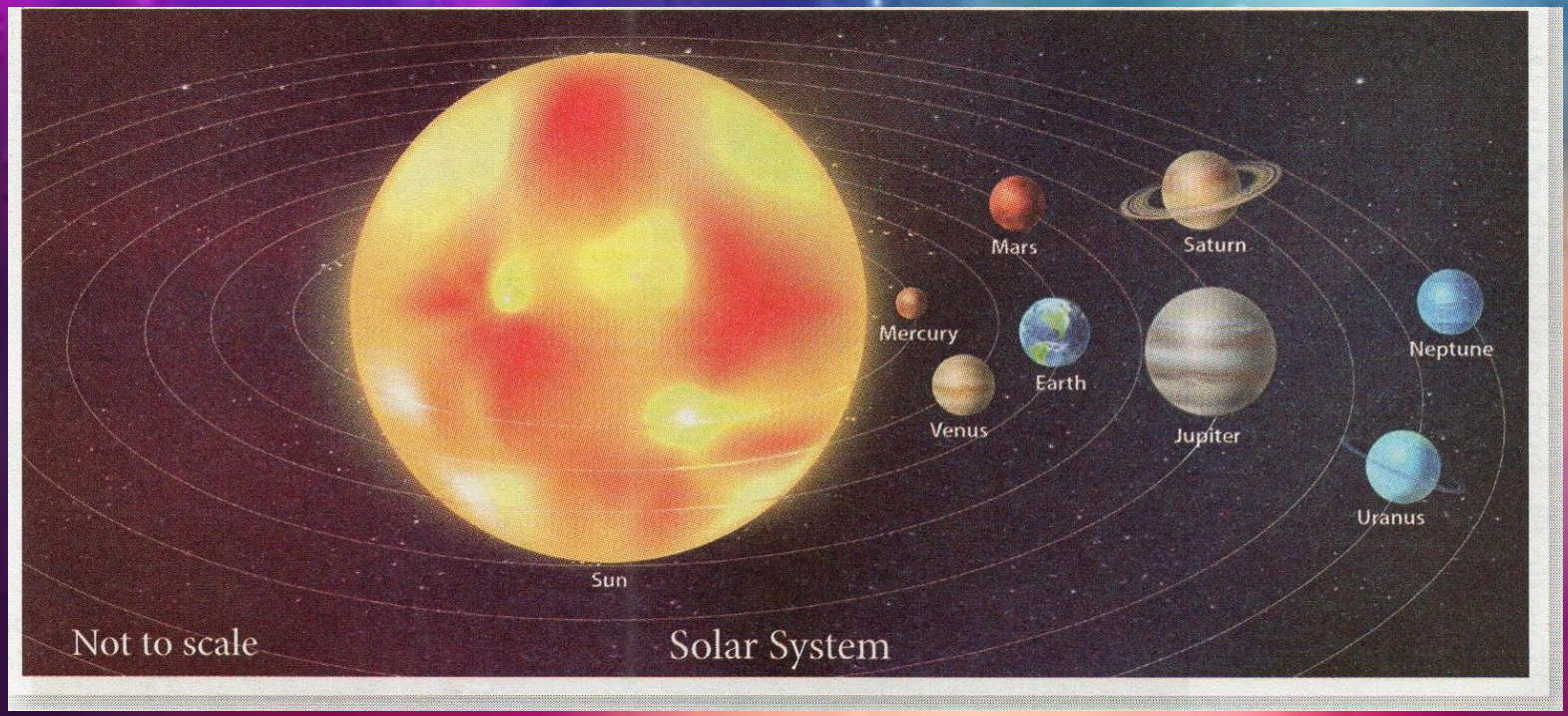
The milky way

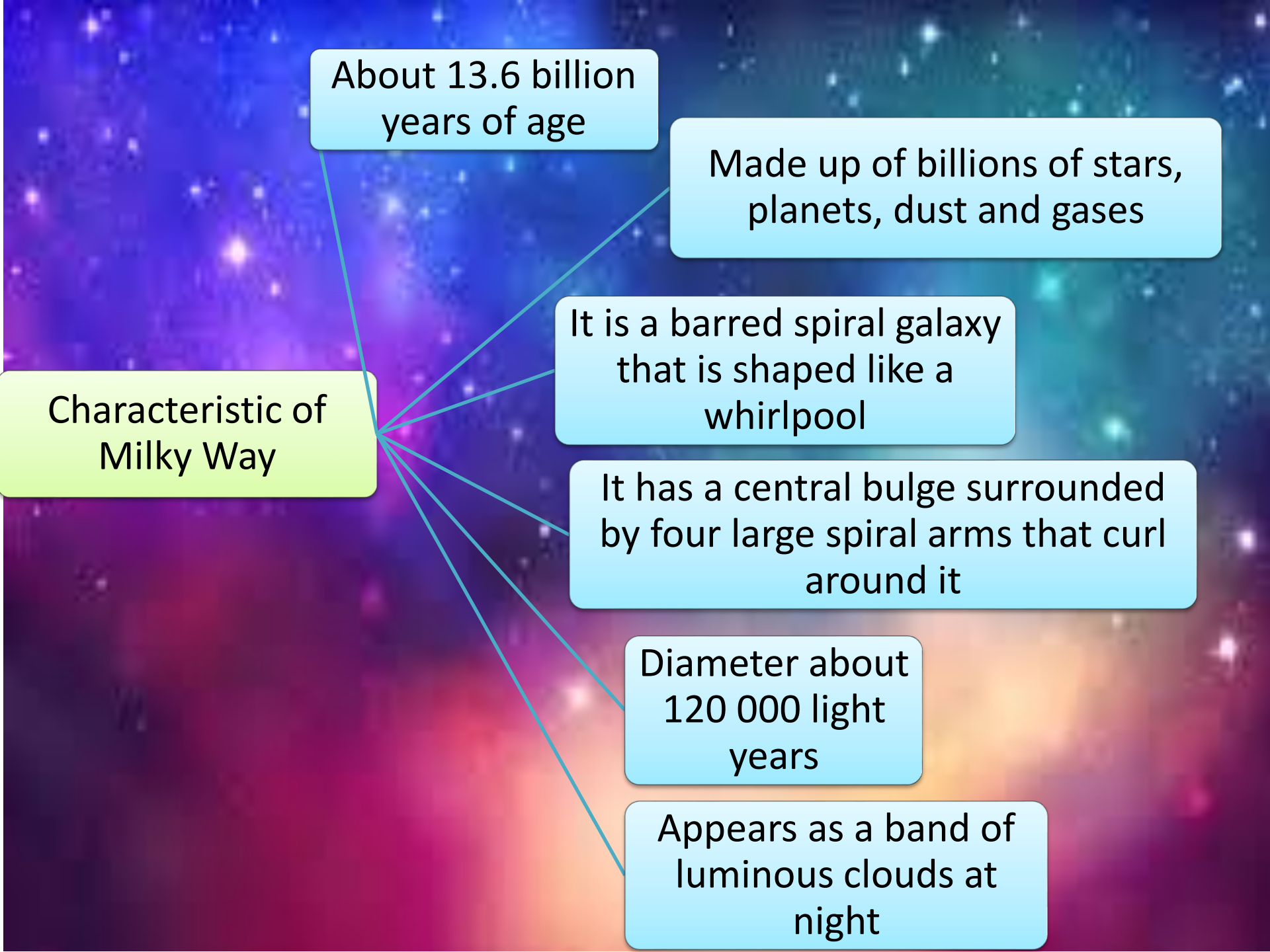
The Milky Way

- The Milky Way is a medium large spiral galaxy
- Our solar system is located at the edge of one of the spiral arms of the Milky Way
- The Milky Way consists of approximately 200 billion stars and the Sun is one of it

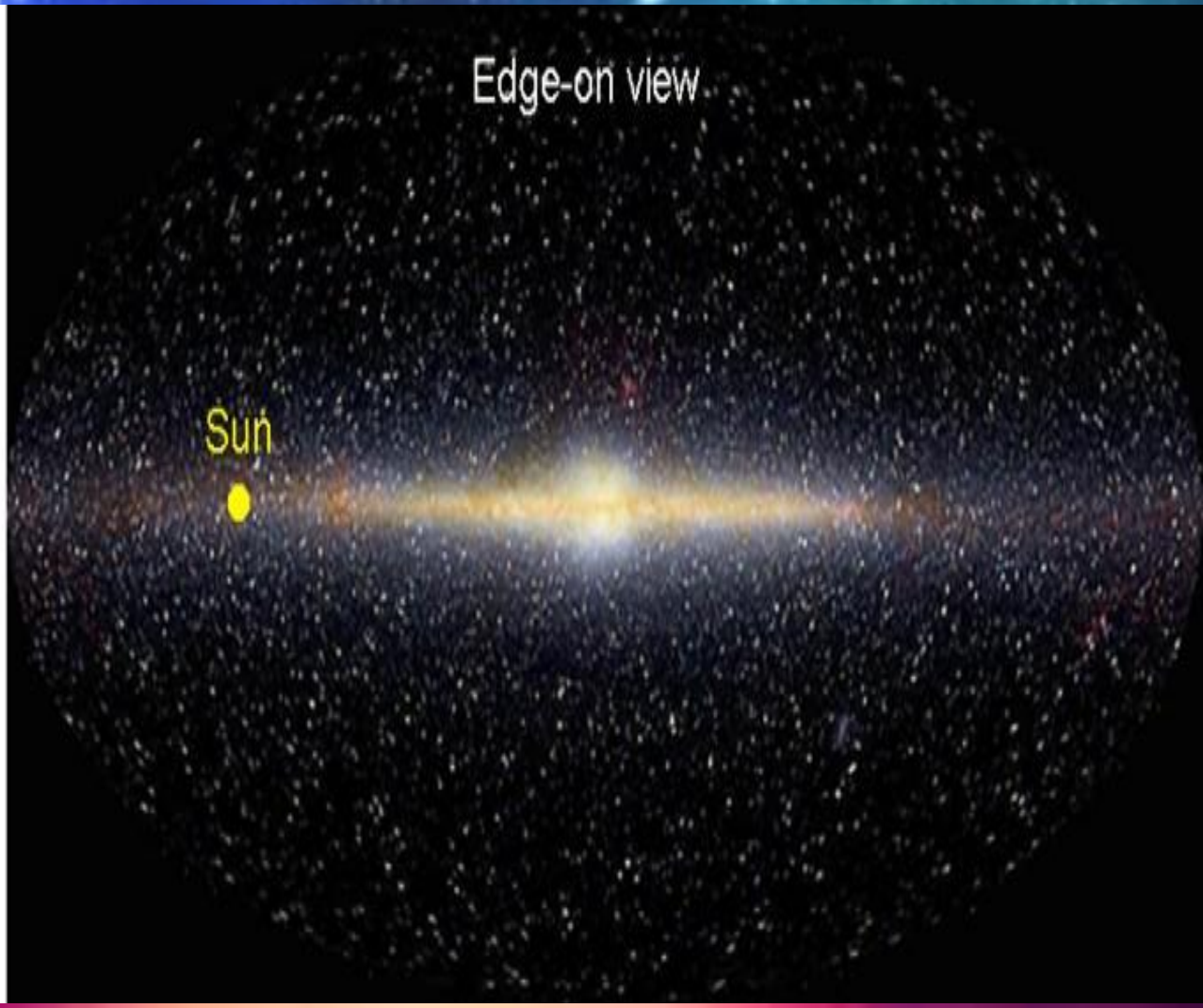

You are here


The Milky Way


Mars
Saturn
Mercury
Earth
Neptune
Venus
Jupiter
Uranus
Sun
Not to scale
Solar System


About 13.6 billion years of age
Made up of billions of stars, planets, dust and gases
Characteristic of Milky Way
It is a barred spiral galaxy that is shaped like a whirlpool
It has a central bulge surrounded by four large spiral arms that curl around it
Diameter about 120 000 light years
Appears as a band of luminous clouds at night

The Sun takes about 225 million years to orbit the centre of the Milky Way



11.1.2 Nebulae

- A nebula (plural: nebulae) is a cloud of dust, helium, hydrogen and plasmas (ionised gases) in outer space.

- Variety of sizes, shapes, and colours

Horsehead nebula

Orion nebula

- Scientists believe that new stars are formed in the nebulae
- Scientists use the nebular hypothesis to explain the formation and life cycle of stars, including our Sun
- The nebular hypothesis was developed by a
- German philosopher named Immanuel Kant in 1755

Birth of stars

Gases and dust particles in a nebula are pulled by a **strong gravitational force** which causes it to form a globe

The strong gravitational force causes the globe of gas to shrink and compress until it becomes very dense and forms a **core**

The core **shrinks** and becomes **dense** due to the increasing strength of the gravitational force.

When the temperature and pressure in the core become too high, a nuclear reaction will take place. **Hydrogen gas** turns into helium. A huge amount of heat energy and light if released

The core will shine and a star is formed.

The star that is formed is known as a protostar

This new star continues to expand and becomes either an **average star** like the Sun or **a massive star (large and heavy)**

Nebular hypothesis

The nebula collapses due to strong gravitational force

The nebula contracts, becoming denser and hotter and swirls more rapidly into a flat spinning disc, with a dense bulge (bonjol) at the centre

The nebula continues to contract until it forms a protostar, which an early form of a star

Then very high temperature and pressure at its core the main sequence star triggers a thermonuclear fusion that generates heat and light energy

When the pressure and gravitational force in the nucleus of the protostar become equilibrium, the protostar turns into a main sequence star (like the Sun)

Death of stars

In a star, a lot of heat is generated which will heat up the outermost layer of the star. As a result, hydrogen within this layer starts to burn.

This causes the star to expand. During this stage, the star appears red in colour and is called a **red giant**.

If the red giant is not massive, a white dwarf is formed

If the red giant is big enough, it contracts so quickly that a big explosion called a **supernova** occurs. A supernova is extremely bright, it can be seen in daylight.

As a result of the explosion, a **neutron star** is formed if the original star is a large star.

If the original star is a super-large star, a black hole is formed. It is called black hole because light in it cannot escape. Any matter that enters it cannot escape too.

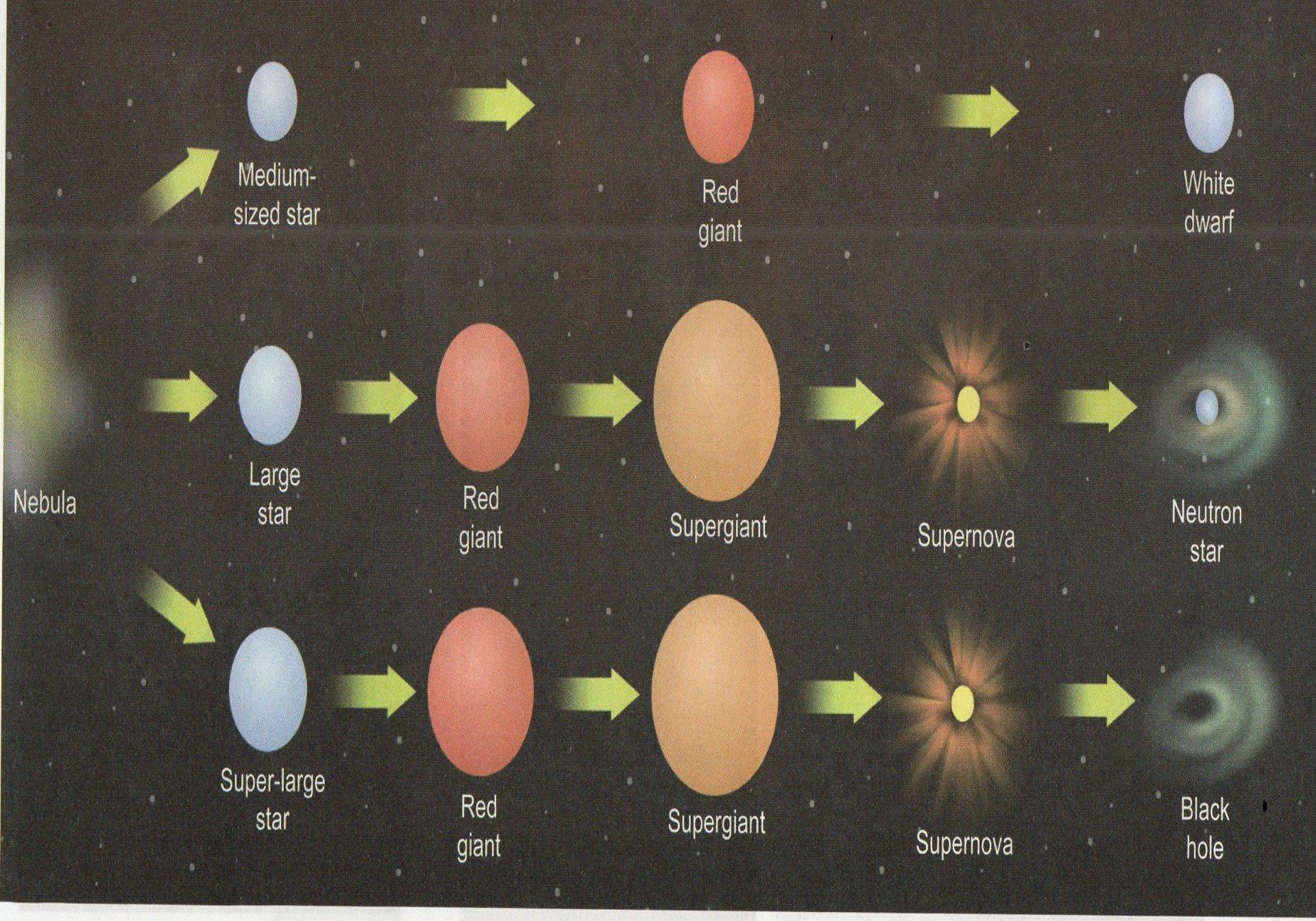
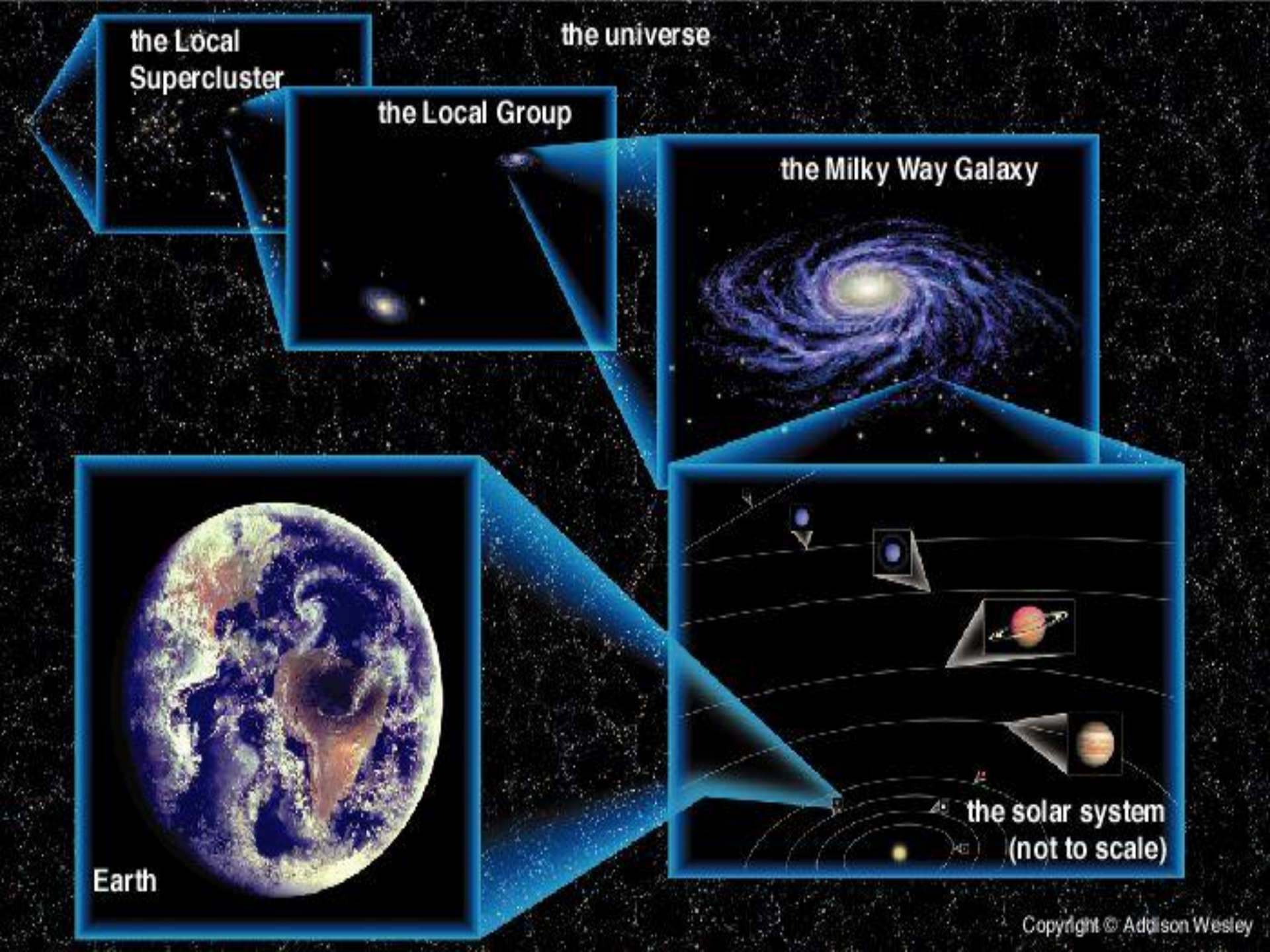


Figure 11.1 *The life cycle of a star*

Relative size of the Earth, planets, the Solar system, the Milky Way and the universe

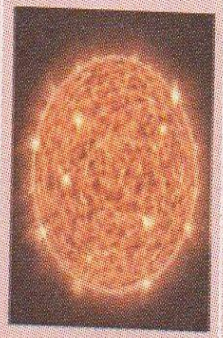


Characteristics of Stars

Colour and temperature

- The colour of a star depends on its temperature
- Blue stars are the hottest and red stars are the coolest

Table 11.1 *Classification of stars based on colour and temperature*

Colour	 Red	 Orange	 Yellow	 Yellowish-white	 White	 Bluish-white	 Blue
Temperature (K)	<3 500	3 500 – 5 000	5 000 – 6 000	6 000 – 7 500	7 500 – 11 000	11 000 – 25 000	>25 000
	Betelgeuse	Arcturus	Sun	Polaris	Sirius	Rigel	Stars of Orion's belt

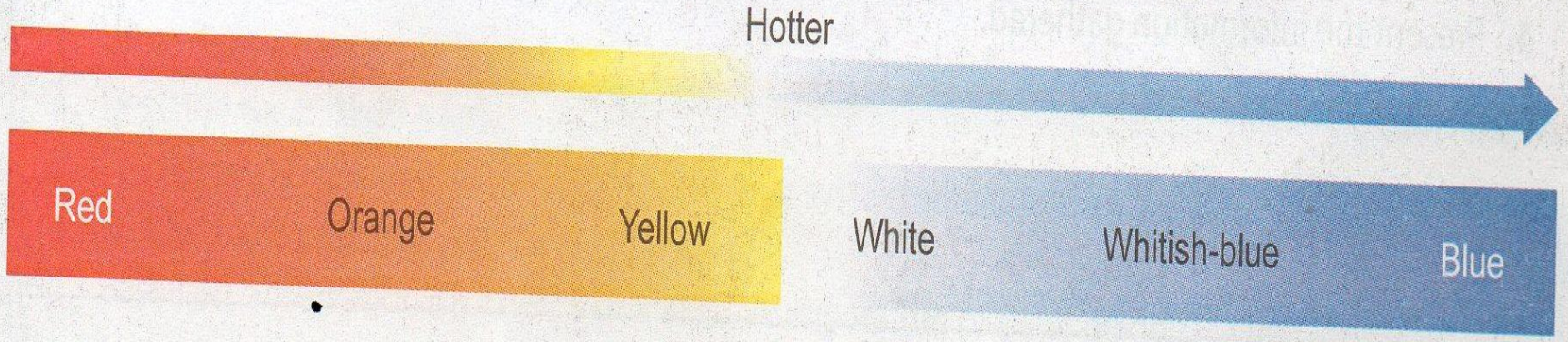


Figure 11.4 *Temperatures of stars for comparison*

Size

- The Sun is a medium sized dwarf star
- Most of the dwarf stars are smaller than the Sun
- The hyper giant stars are the largest stars in the universe.

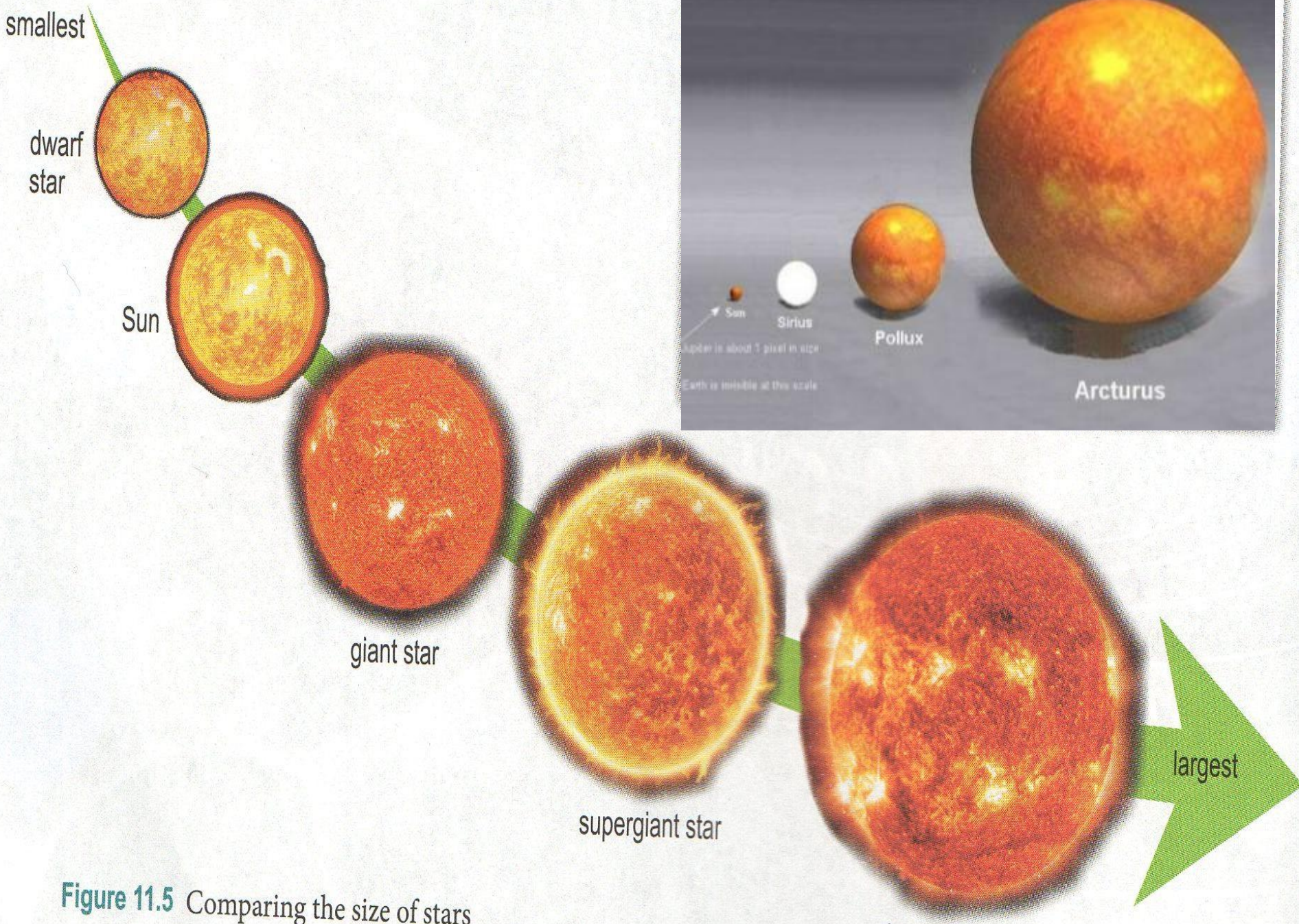
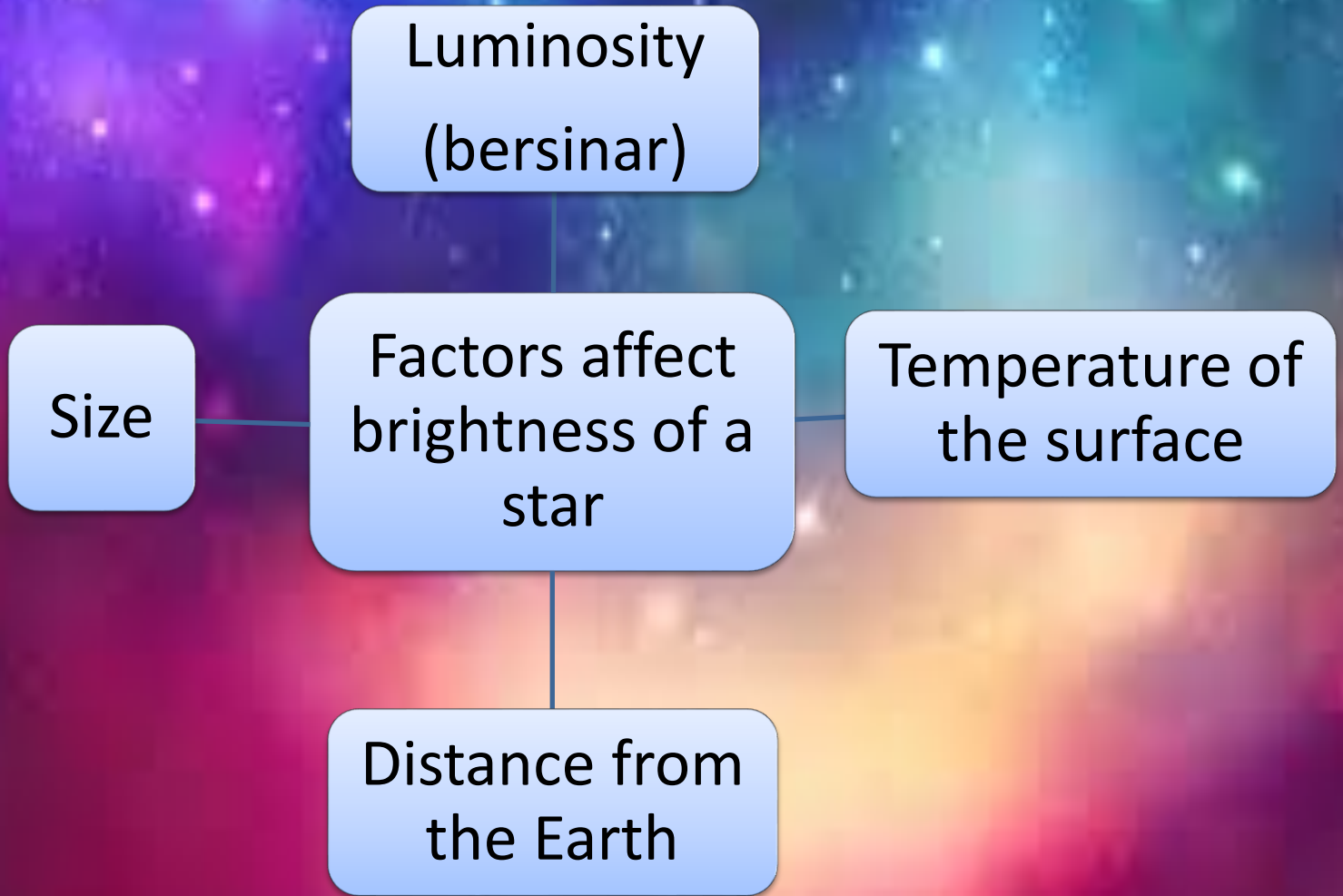


Figure 11.5 Comparing the size of stars

Brightness

- The brightness of a star depends on the following factors:



Brightness

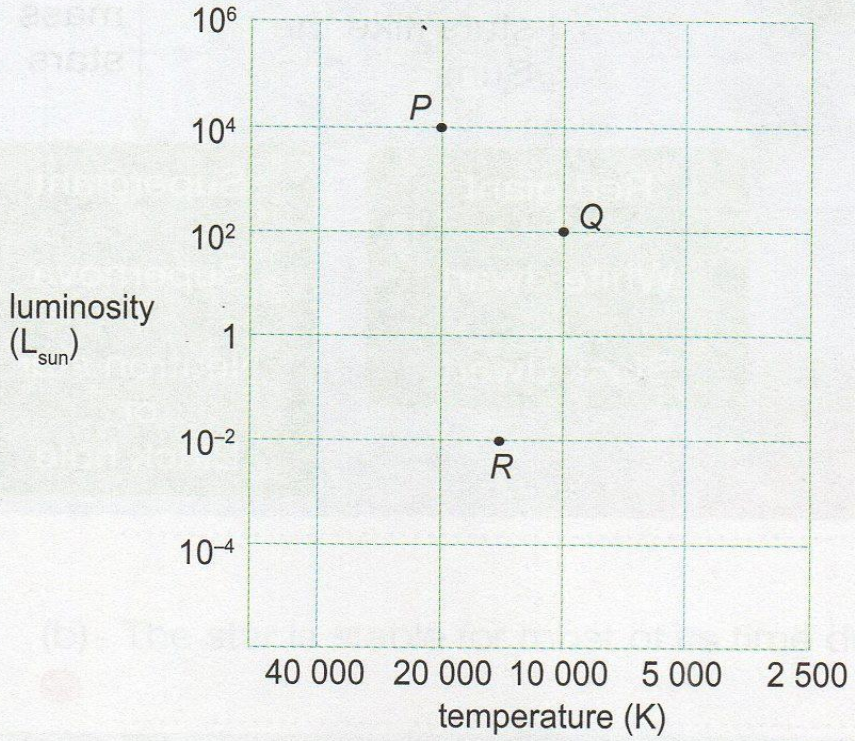
- A star appears brighter is it is bigger, hotter, more luminous and closer to Earth
- A star appears dimmer if it is smaller, cooler, less luminous and further away from Earth.
- The luminosity of the stars is the amount of light energy emitted by the surface of the star

Distance

- The Sun is closest star to the Earth, which is about 150 million kilometres away
- The distance between the Earth and the Sun is called astronomical unit (AU)
- The second closest star to the Earth is Proxima Centauri

HOTS Guide

The Hertzsprung-Russell diagram below shows the luminosity and the temperature of three objects in space, *P*, *Q* and *R*.



(a) Which object is the hottest and brightest? [1 *mark*]

(b) Which object is the coolest and dimmest? [1 *mark*]

(c) Can the Hertzsprung-Russell diagram be used to show the characteristics of Earth? Explain your answer. [3 *marks*]

(d) (i) Circle the type of star that is represented by object *R*.

Red giant	Supergiant	White dwarf

[1 *mark*]

(ii) Explain the reason for your answer. [2 *marks*]

HOTS level

Analysing, Evaluating

Answer guide

Objects *P*, *Q* and *R* are stars that have different brightness and surface temperatures. The brighter the star, the greater the luminosity. Star *P* is a main sequence star, star *Q* is a red giant, and star *R* is a dimmed white dwarf.

Sample answer

(a) *P* (1m)

(b) *R* (1m)

(c) Cannot (1m) This is because the temperature (1m) of Earth is too low (1m) and it does not emit light energy like stars do (1m).

(c) (i) White dwarf (1m)

(ii) The white dwarf is formed from a collapsed (1m), dying red giant star (1m). Therefore, its surface is dimmed.