SCIENTIFIC CASE:

Study of Hertzsprung-Russell Diagram

Team members

Writer: ____

Equipment manager: ___________________________________

Spokesperson/Ambassador:_______________________________

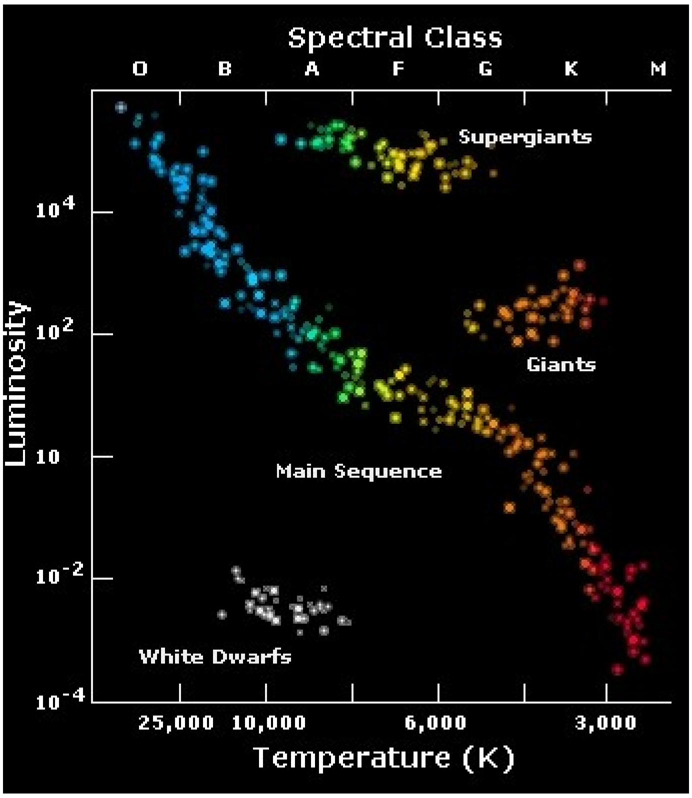
Context

An open star cluster is a group of stars which were originally formed from the same initial gas cloud (mostly hydrogen). These clusters can be made up of dozens or hundreds of stars.

Open star clusters are excellent astronomical laboratories. The stars that form one are all equally as far from us, they move in the same direction, they are approximately the same age, and they have about the same chemical composition. Thus, **when we see differences between the brightness of different stars in the same cluster, we know that it can only be because they have different masses**. Studying several clusters, we can compare them and know more about stellar evolution, clusters' ages, and much more.

*The **Pleiades.** NASA, ESA, AURA/Caltech, Palomar Observatory.*
Source: http://hubblesite.org/newscenter/archive/releases/2004/20/image/a/Author

This and other research have allowed us to find out the different types of stars that exist and how most of them evolve. Take a minute to understand the following plot.

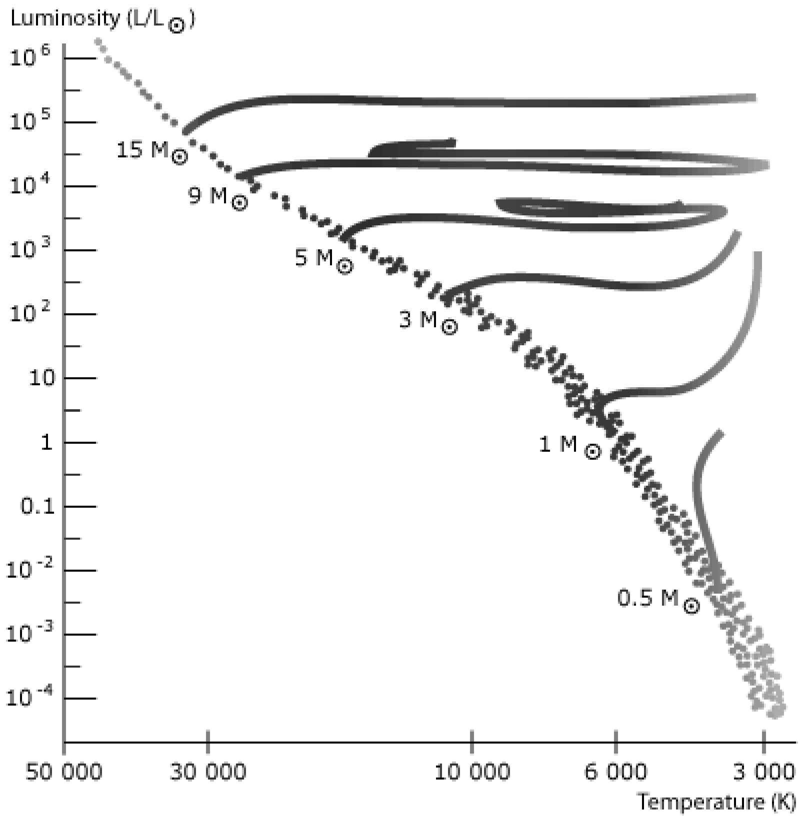


Hertzsprung-Russell Diagram. Credit: ESA.

http://sci.esa.int/education/35774-stellar-radiation-stellar-types/?fbodylongid=1703

Nearly all stars are in one of the places shown on the graph. For instance, there are no blue stars with luminosity 10. But there are, in fact, stars with luminosity 10^4 (10^4 = 10000, remember scientific notation). Also, as you can see, most of them are in the **Main Sequence**.

Each star has an age, and because they can live thousands of millions os years, we can only known how they evolve by observing relationships between different stars. In the following plot, you can see how some of them change over time. That is, we took some stars (dots) and we traced a line that describes how their temperature changes over time.



HR Diagram showing paths of stars with different masses. Credit: ESA.

http://sci.esa.int/jump.cfm?oid=36828

More educational resources:

Hertzsprung-Russell Diagram: http://sci.esa.int/jump.cfm?oid=35774

CESAR: http://www.cosmos.esa.int/web/cesar
ESA education: http://sci.esa.int/education/

Scientific case: Study of Hertzsprung-Russell Diagram

We are going to study the evolution of an arbitrary star: the Sun.

Research equipment:

You have access to these:

- Colour pencils, paper, rubber.
- Sellotape/glue stick. Scissors.
- H-R Diagram poster.
- Cutouts with information about different stars.

Procedure

1. Each team will be given coutouts with incomplete information about some celestial objects (**all of them are, have been, or will be, similar to the Sun**).

Name of the celestial object	
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description

2. You **first mission** is to unify the cutouts. Start by matching every image with its description. Watch out: it is likely that the corresponding match to your image or description is in the hands of another team. You will have to work together!

3. Every single one of the six images, together with their description, shows a moment in the life of a star. Another piece of the cutout containing different data will be handed out to you. You have to asign an age to every set of image + description, the written information will help you do it.

Age (years)	
Radius (compared to the Sun's)	
Temperature (compared to the Sun's)	
Brightness (compared to the Sun's)	

4. When every team agrees on the result, you can continue and complete the poster which is hanging on the wall with a H-R diagram. This graphic contains six blue circles where the cutouts should go. It also traces a line that describes the Sun's evolution from its birth to its death.

5. The aim of the **second mission** is to glue the cutouts you have (image + description + age) on the correct spot of the diagram. Tip: look at the axis of the diagram to find out what part of your information you can use.

6. Observing where other groups place the cutouts on the diagram is vital to achieve the whole picture.

7. If you have any doubts, ask the educators or other groups. Never hesitate to ask questions and share your work with others!

Research equipment

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Cutouts with information regarding different celestial objects[1]

1 Info based on “Interactive H-R Diagram”. By Edward Gomez & Jon Yardley

Name of the celestial object	M42: Orion Nebula.
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description
Stelar Nursery. An interstellar cloud of mostly hydrogen begins to collapse under the force of gravity. As the cloud collapses the region of gas heats up and gets brighter (the total brightness goes down because the region gets much smaller). This region has enough mass for a nuclear fire to ignite in its core, once gas gets to the critical density. The nuclear fire burns hydrogen to form helium.

Age (years)	0 Years
Radius (compared to the Sun's)	-
Temperature (compared to the Sun's)	-
Brightness (compared to the Sun's)	-

Name of the celestial object	M17: Swan Nebula.
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description
Protostar. Many protoplanetary discs in this nebula. Once fusion starts in the core of the collapsing cloud, a protostar has formed. These are very difficult to observe because they are hidden by a planet-forming disc.

Age (years)	20.000.000
Radius (compared to the Sun's)	3
Temperature (compared to the Sun's)	0,5
Brightness (compared to the Sun's)	1

Name of the celestial object	M23
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description
Open cluster. This is a cluster of young stars, many of which are at the Main Sequence phase of their lives. The protostar has remained approximately the same brightness but surface temperature increased as it continued to get smaller. It has now joined the main sequence where it will spend most of its life. The star is now **very similar to the Sun today**.

Age (years)	1.050.000.000
Radius (compared to the Sun's)	1
Temperature (compared to the Sun's)	1
Brightness (compared to the Sun's)	1

Name of the celestial object	M 80
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description
Globular cluster. This contains some of the Galaxy's oldest stars in the Red Giant phase. After slowly burning through the hydrogen in core, helium is explosively ignited, forming heavier elements. The core heats up and the pressure inside the star increases, which makes the star swell to 100 times the Sun's radius. The total brightness of the star increases but because it is now much larger, the surface temperature is lower than the Sun's.

Age (years)	11.050.000.000
Radius (compared to the Sun's)	100
Temperature (compared to the Sun's)	0,5
Brightness (compared to the Sun's)	1000

Name of the celestial object	M76: The little dumbell nebula.

Image (credit: taken by Robert J. Vanderbei.).

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Description

A planetary nebula.
The swollen red giant begins to expand and contract, while helium burns in the core. These pulsations eventually lead to the outer layers of the star being completely ejected, forming a colourful planetary nebula.
The very hot core of the star is left behind, which is called a White Dwarf star.

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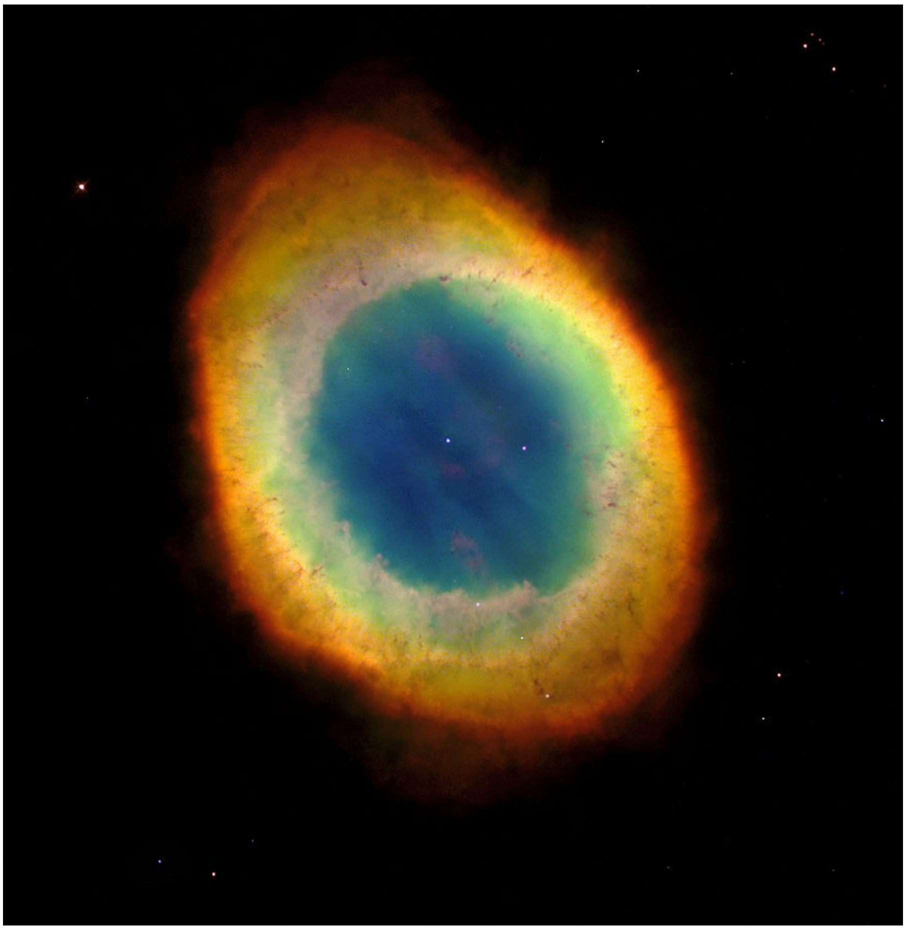
Age (years)	11.050.000.000
Radius (compared to the Sun's)	0,01
Temperature (compared to the Sun's)	10^5
Brightness (compared to the Sun's)	1000

Name of the celestial object	M57: Ring Nebula.

Image (credit: ESA, NASA. Hubble Space Telescope)



Description
The white dwarf can be seen at the centre of expanding nebula. The core of the star is very hot, bright and incredibly dense, but without the outer layers the pressure at the centre is not high enough to continue the fusion fire. The star enters its final phase where it gradually gets cooler and fainter.

Age (years)	11.050.000.000
Radius (compared to the Sun's)	0,01
Temperature (compared to the Sun's)	20
Brightness (compared to the Sun's)	100

Name of the celestial object	
Image (credit: ESA, NASA. Hubble Space Telescope)	

Description

Age (years)	
Radius (compared to the Sun's)	
Temperature (compared to the Sun's)	-
Brightness (compared to the Sun's)	-

POSTER H-R diagram Sun Evolution (FOR PRINT USE “POSTER-Hrdiagram-Sun-Evolution.jpeg”).