COMPARING STARS

In this session, students will plot, label and interpret the Hertzsprung–Russell Diagram. The diagram shows a relationship between a star's absolute magnitude (luminosity) and its temperature. It was created by astronomers Ejnar Hertzsprung and Henry Norris Russell about 1910, and can be used to chart the life cycle, or evolution, of a star.

Learning Objectives, students will learn:

1. that stars have different luminosities and surface temperatures
2. that a star's position on the chart is linked to the star's size and age
3. to plot, label and interpret the HR diagram

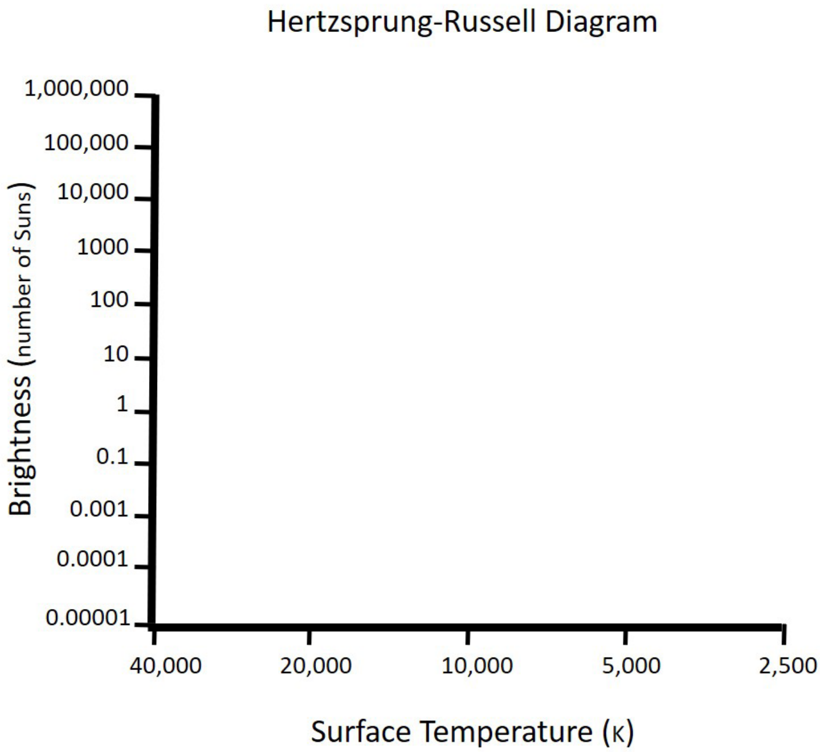
   *The star circles are at the end of this document.

Each group will require the following:

REQUIRED RESOURCES
☆ Sticky notes
☆ Pens or pencils
☆ Large poster paper
☆ Colour-printed star circles*
☆ Scissors
☆ Glue sticks (optional)

Before the Session:

1. Print and cut out the star circles. There are a lot so you may want to get a volunteer to help you! Alternatively, chop the sheets up into pieces with about 3 star circles on each. Students can cut out their own stars at the start of Activity 2.
2. Find a large sheet of paper or stick several large sheets together. The bigger the better, as your whole club will be working together to plot the star data on it. Alternatively you could mark out a large space on the floor using masking tape.
3. Draw and label the axes on the paper so that it looks like the template (right).



IMPORTANT

Notice that the x-axis (horizontal) shows temperature in Kelvin. The y-axis (vertical) shows brightness in terms of number of times the brightness of our Sun. Note that neither axis is linear, this is so the data is easier to plot.

ACTIVITY 1: WHO AM I?

The aim of the game is for one student to determine the star life-stage written on the sticky-note stuck to their head. They do this by asking their partner questions and using the information on their sheets.

1. Put students into pairs or small groups and introduce the activity.
2. Hand out sticky-notes and something to write with.
3. Remind students to use the instructions and information in their sheets.
4. Give the students 5 – 10 minutes for this activity.

ACTIVITY 2: CREATE A HERTZSPRUNG–RUSSELL DIAGRAM

The group will work together to create a Hertzsprung–Russell diagram. They will use the star circles and large blank chart you prepared before the session. The activity should take about 30 - 40 minutes. This activity is adapted from 'Astrobiology: An Integrated Science Approach', 2005, TERC, Cambridge, MA, USA. We have included some discussion prompts and background information to help you and the club understand and interpret the diagram.

Instructions:

1. Introduce the activity to the students and hand out the star circles. Each student should have 3 – 6 star circles, but this will depend on the size of your club.
2. Ask students to take turns adding their data to the chart. Make sure they check the chart carefully – taking into consideration that the axis are not scaled linearly. Your club may opt to use glue sticks to fix their stars in place.
3. Encourage the students to ask inquisitive and scientific questions about what they are seeing as they complete the chart. Many students may be surprised that stars come in so many colours, temperatures and luminosities.
4. Keep going until all the data is plotted.

Suggested questions for the students to discuss and answer:

- ☆ What do you notice about the scales on the axes?
- ☆ Can you see a main trend?
- ☆ What is the relationship between temperature and brightness?
- ☆ Which types of stars fall outside the main trend line? Describe them. What are the differences between them?
- ☆ What is the colour of the brightest stars? What about the dimmest?
- ☆ What is the colour of the hottest stars? What about the coolest?
- ☆ Why might stars of one colour be much more abundant than stars of another colour?

The following information will help you and the students to understand and interpret the diagram:

1. Most stars can be found on the Main Sequence - a prominent band running from the top-left to the bottom-right of the diagram. On the Main Sequence we find that the hotter a star is, the greater its luminosity. Both these factors are determined by the stars mass.

2. Giant and Supergiant stars expand in the final stages of their lives. As a result of this they become cooler. But because they are so big, they are very bright, and so appear above and to the right of the Main Sequence.

3. White Dwarfs are extremely hot and dense, but because of their small size, they are not very luminous. As a result, they can be found below and to the left of the Main Sequence.

4. In general, stars will spend most of their life (~90%) on the Main Sequence before evolving into a giant star for the remaining 10%. Following that, they will either go supernova or become a white dwarf.

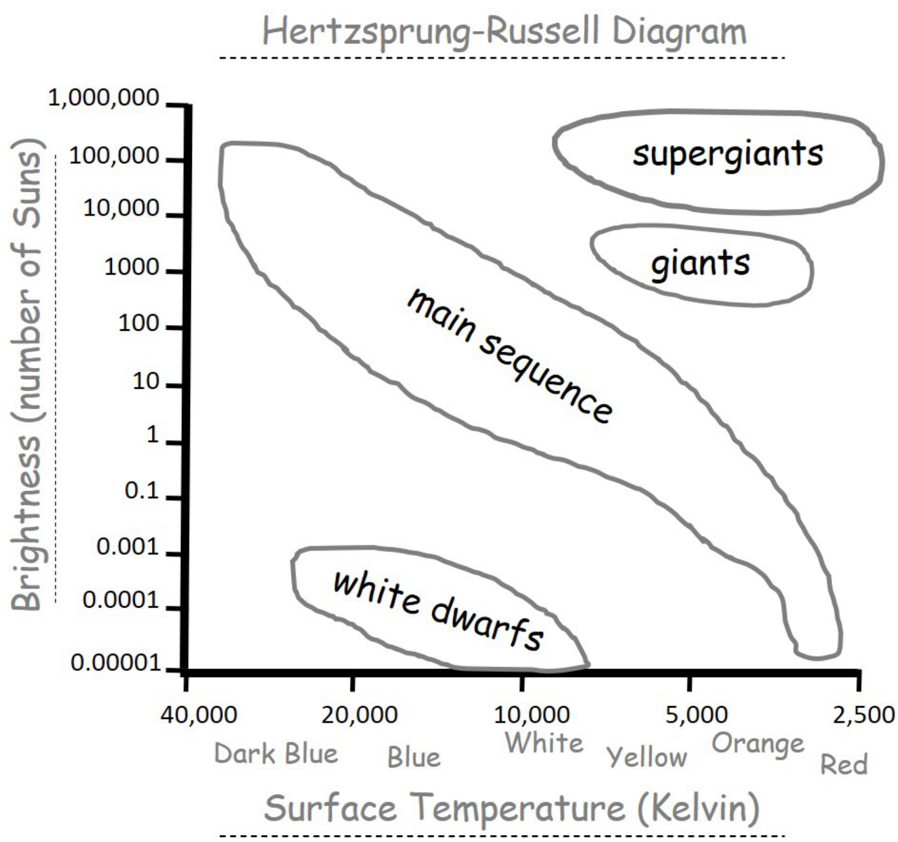
5. The Sun is currently in the Main Sequence stage. In the future it will become a red giant, and then a white dwarf.

6. The x-axis (horizontal axis) of the Hertzsprung–Russell Diagram can be given in many different forms, such as the star's temperature (Kelvin), its spectral class (OBAFGKM) or its colour.

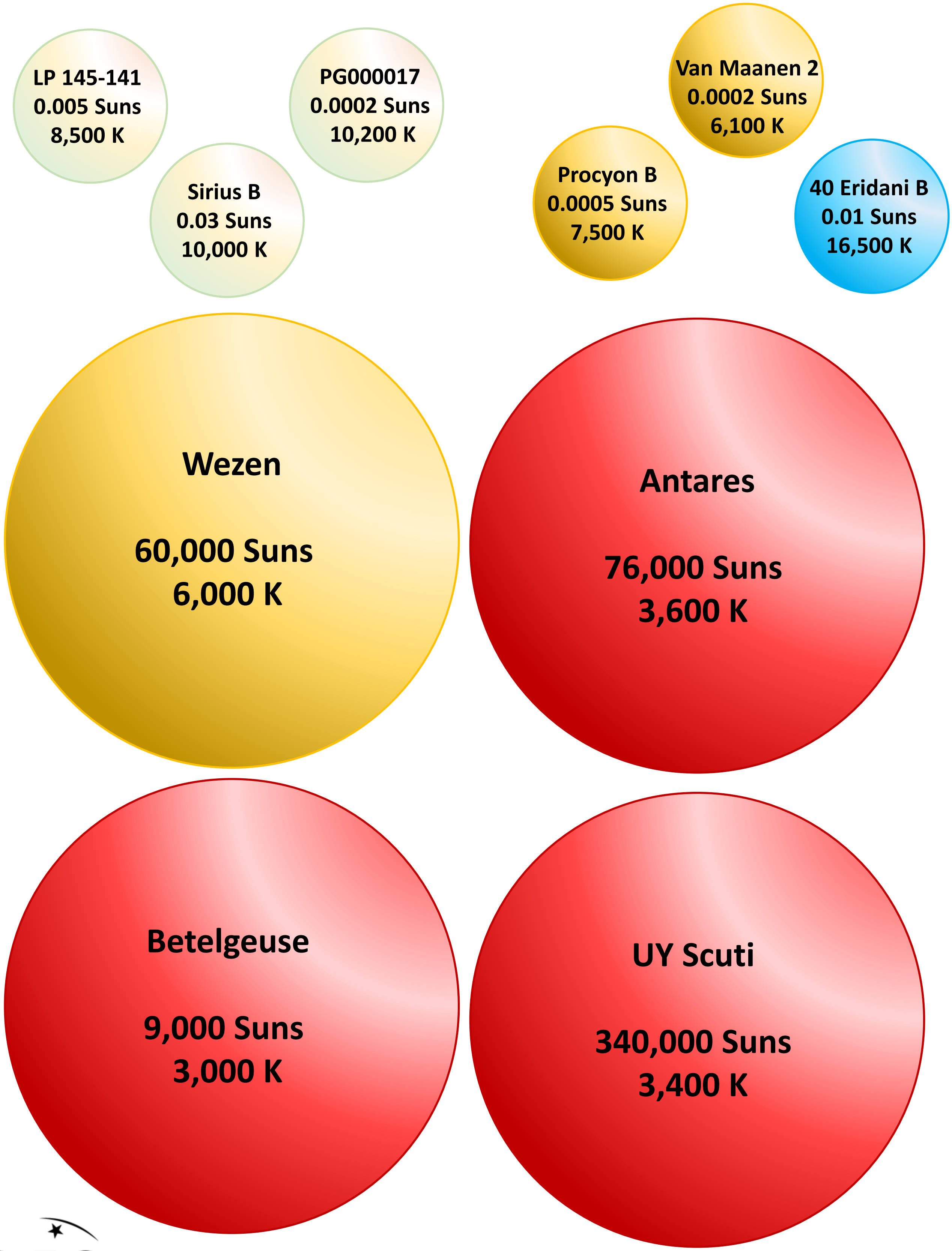
ACTIVITY 3: USING THE HERTZSPRUNG–RUSSELL DIAGRAM

Students use the Hertzsprung–Russell diagram they have just created to draw a sketch of the chart and complete the questions on their sheets. Remind students that this should be a rough sketch and they do not need to draw each individual star.

Their completed chart should look like this:



ACTIVITY 2: STAR CIRCLES



Mu Geminorum

310 Suns
3,100 K

DC0020938

320 Suns
3,200 K

Aldebaran

440 Suns
3,900 K

Mirach

480 Suns
3,200 K

Aldebaran

440 Suns
3,900 K

Arcturus

170 Suns
4,000 K

Ruchbah

70 Suns

15,000 K

Kaffaljidhma

25 Suns
14,000 K

Sheratan

25 Suns
12,000 K

XXR86

66 Suns
10,000 K

SAC9899

72 Suns
10,400 K

YEZ8872

88 Suns
10,400 K

LP033276

0.001 Suns
11,100 K

Alpheratz

132 Suns
22,000 K

Mintaka

10,000 Suns
40,000 K

K073491

120 Suns
35,000 K

JAC64932

101 Suns
38,000 K

RTL6439

81 Suns
26,000 K

JAC04320

90 Suns
22,000 K

Spica

20,000 Suns
25,500 K

Phaet

480 Suns
20,000 K

Acamar

110 Suns
20,000 K

APAC617

0.02 Suns

4,100 K

DC0032864

0.06 Suns
4,200 K

DC0029876

0.04 Suns
4,300 K

JAC12967

0.09 Suns
4,200 K

DAAC329

0.09 Suns
4,200 K

JAC43928

0.07 Suns
4,100 K

Epsilon Eri

0.28 Suns
4,200 K

Epsilon Indus

0.16 Suns
4,200 K

61CygA

0.04 Suns
4,200 K

61CygB

0.05 Suns
4,200 K

Procyon

8 Suns
8,600 K

Sirius

23 Suns
9,800 K

Castor

19 Suns
9,800 K

Hassaleh

3 Suns
8,300 K

XXR42

19 Suns
9,200 K

SAC2243

29 Suns
9,400 K

WZ443

60 Suns
9,000 K

SAC5430

28 Suns
9,700 K

XXR49

22 Suns
9,900 K

PL0089 0.3 Suns 4,800 K	PL00932 0.5 Suns 5,200 K	ARN93227 0.7 Suns 5,000 K	SL9-67294 1.6 Suns 6,200 K
Tau Cetus 0.5 Suns 5,200 K	YEZ8732 0.8 Suns 5,400 K	G757 2.3 Suns 5,800 K	CST6128 1.9 Suns 5,800 K
BSC3430 3 Suns 5,900 K	RTL9847 2 Suns 6,000 K	DAAC328 1.6 Suns 6,200 K	APAC529 1.7 Suns 6,100 K
BDE00017 1.0 Suns 5,900 K	Beta Sagittae 300 Suns 6,000 K	JAC57492 1.2 Suns 5,900 K	JAC7632 0.8 Suns 5,900 K
Sun 1 Suns 4,800 K	BDE10298 0.01 Suns 3,900 K	KO65430 0.01 Suns 3,500 K	JAC76582 0.04 Suns 3,800 K
CRTP987 0.08 Suns 3,600 K	JAC39672 0.02 Suns 3,900 K	APAC424 0.01 Suns 3,900 K	Barnard's Star 0.0003 Suns 3,000 K

Wolf 359
0.00002 Suns
2,900 K

BD + 362147
0.005 Suns
3,500 K

L726-8A
0.00006 Suns
3,000 K

L726-8B
0.00005 Suns
3,000 K

Ross 154
0.0005 Suns
3,000 K

Ross 248
0.0004 Suns
3,000 K

BD591915A
0.0006 Suns
3,100 K

CD3615693
0.0001 Suns
3,300 K

Ross 128
0.0003 Suns
3,200 K

L789ABC
0.0001 Suns
3,200 K

L37258
0.0001 Suns
3,200 K

BD51668
0.0006 Suns
3,000 K

B0591915B
0.0005 Suns
3,000 K

L72532
0.0002 Suns
2,900 K

BLG9982
0.009 Suns
3,000 K

MGU82067
0.0001 Suns
3,100 K

Kapteyn's Star
0.004 Suns
3,500 K

CD3914192
0.03 Suns
3,600 K

Kruger 60A
0.0006 Suns
3,200 K

CD2510553
0.00004 Suns
3,000 K

Ross 614A
0.00007 Suns
3,000 K

Ross 614B
0.00001 Suns
2,900 K

Proxima
0.00005 Suns
2,900 K