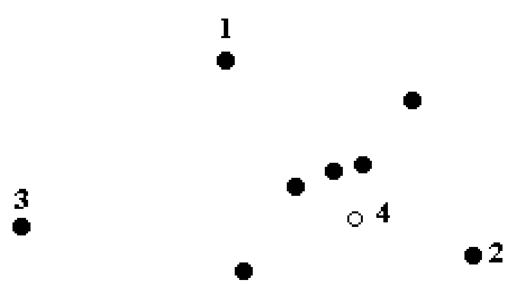
Hertzsprung-Russell Diagram

The H-R Diagram is a fundamental discovery that led to modern astronomy. Most students can understand it. All benefit from the valuable math experiences in it.

The H-R diagram compares the star's temperature to its luminosity. It is important because it shows that only a small number of star types exist, and not all possible combinations of temperature and luminosity as was previously thought. Students will be able to see from their plots that the star types cluster in separate areas on the grid. They will then be able to tell you the temperature and luminosity of each group; you can lead them to determine the size of the stars. The names are logical: Main Sequence (most stars), White Dwarfs (very hot, low luminosity), Red Giants and Super Giants (cool, very bright).

The axes on the H-R diagram are a useful math review. Ask the class what is wrong with the x-axis. (The numbers decrease to the right *backwards* and are not evenly spaced. This is because the original plot used spectral classes of stars, which is based on colour. When the colours were converted to temperature °K the result was this odd direction and numbering.) Next, ask what is odd about the y-axis? (It is logarithmic. Most students will be unfamiliar with it and will need help to plot on it.) Point out that its major divisions go up by powers of 10 – which is necessary in plotting very small to very large luminosities. You can easily help them by plotting 30, 300 and 3000 on an enlarged axis on the board.

It is important to encourage your students to turn to the sky and try to identify examples of the different star types. A good reference for you and the students is *Night Watch, An Equinox Guide to Viewing the Universe*, by Terence Dickinson published by Camden House (~$25.00). It has star charts, how to observe the night sky, planet watches and more. The star charts give a wealth of data about individual stars including distance, magnitude and type. A good place for them to start looking is at the constellation Orion (below).



1. **BETELGEUSE** (the armpit of the giant) Red Super Giant, 520 light years away
2. **RIGEL** Blue White Super Giant, 900 light years away
3. **SIRIUS** (about 2 hand spans from the belt stars) Blue White Giant, the brightest star we can see, 8.7 light years away
4. **ORION** Nebula, hazy patch to the naked eye

So why don't we see any White Dwarfs? Two reasons: none are near and they are too dim.

Student Exercise

Hertzsprung-Russell Diagram

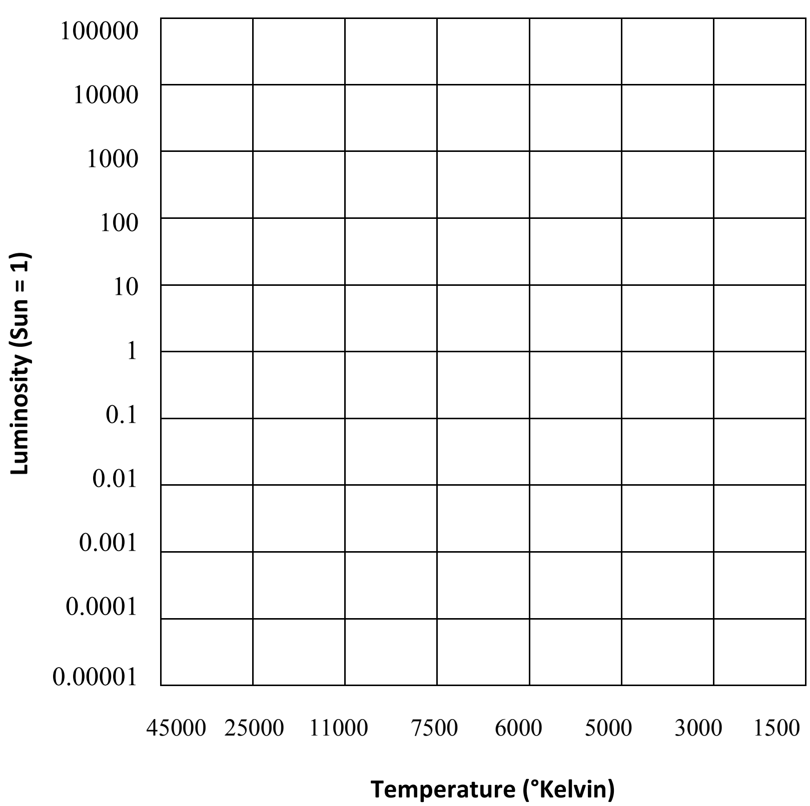
Purpose:

To study a method by which the types of stars can be determined.

In 1912, two astronomers, Hertzsprung (in Holland) and Russell (in USA), independently studied the relationship between the temperature and luminosity for a large group of stars. These properties were plotted on a graph which led to the discovery that stars exist as only a few types and not as a range of all possible combinations of temperature and luminosity. This graph became known as the H – R Diagram and a great deal of modern astronomy is based on it.

Procedures:

On the grid provided, plot the temperature and luminosity of the stars listed. Do not join the points with a line.



Student Exercise

Questions:

1. Examine the axes of the graph. How are they numbered? Is this the normal method of numbering? Why is this method used here?

2. Where is the Sun located on the graph?

3. The plotted points seem to be broken into three distinct groups. Describe each.

4. Where do most of the points fit on the graph?

5. Where is the smallest group of stars located on the graph?

6. What is the significance of the H-R Diagram to modern astronomy?

Student Exercise

Table 1

Star	Visual Magnitude	Distance (light years)	Temperature (° Kelvin)	Luminosity
Brightest Stars				
Canopus	-0.72	100.0	7,400	1500.0
Alpha Centauri A	-0.01	4.3	5,800	1.5
Arcturus	-0.06	36	4,500	110.0
Vega	+0.04	26.0	10,700	55.0
Rigel	+0.14	800.0	11,800	40,000.0
Procyon A	+0.38	11.3	6,500	7.3
Betelgeuse	+0.41	500.0	3,200	17,000.0
Achernar	+0.51	65.0	14,000	200.0
Beta Centauri	+0.63	300.0	21,000	5,000.0
Altair	+0.77	16.5	8,000	11.0
Aldebaran	+0.86	53.0	4,200	100.0
Spica	+0.91	260.0	21,000	2800.0
Antares	+0.92	400.0	3,400	5,000.0
Deneb	+1.26	1,400.0	9,900	60,000.0
Nearest Stars				
Sun	-26.7	0.00002	5,800	1.0
Alpha Centauri A	-0.01	4.3	5,800	1.5
Alpha Centauri B	+1.4	4.3	4,200	.33
Alpha Centauri C	+11.0	4.3	2,800	0.0001
Wolf 359	+13.66	7.7	2,700	0.00003
Lalande 21185	+7.47	8.1	3,200	0.0055
Sirius A	-1.43	8.7	10,400	23.0
Luyten 726-8 A	+12.5	8.7	2,700	0.00006
Ross 154	+10.6	9.6	2,800	0.00041
Epsilon Eridani	+3.73	10.8	4,500	0.30
Ross 128	+11.13	11.0	2,800	0.00054
Luyten 789-6	+12.58	11.0	2,700	0.00009
61 Cygni A	+5.19	11.1	4,200	0.084
61 Cygni B	+6.02	11.1	3,900	0.039
Procyon A	+0.38	11.3	6,500	7.3
Procyon B	+10.7	11.3	7,400	0.00055
Epsilon Indi	+4.73	11.4	4,200	0.14

Star	Visual Magnitude	Distance (light years)	Temperature (° Kelvin)	Luminosity
Other Stars				
Delta Aquarii	+3.28	84	9,400	24.0
Beta Cassiopeiae	+2.26	45	6,700	8.2
02 Eridani B	+9.5	16	11,000	0.0028
L879-14	+14.10	63?	6,300	0.00068
70 Ophiuchi A	+4.3	17	5,100	0.6
Delta Persei	+3.03	590	17,000	1,300.0
Zeta Persei A	+2.83	465	24,000	16,000.0
Tau Scorpii	+2.82	233	25,000	2,500.0
Van Maanen's Star	+12.36	14	7,500	0.00016