The Fates of Stars

Two simple relations are of extreme importance in stellar evolution.

Mass-Luminosity Relation: $L \propto M^4$

Lifetime Relation: $t_{life} \propto M / L = 1 / M^3$

Keep in mind these are only approximations - rules of thumb that have been shown to fit the data reasonably well, not fundamental laws of nature (like the inverse-square or Stefan-Boltzmann laws.) Furthermore, they *only* work for main-sequence stars: once a star uses up its hydrogen fuel at its center, its luminosity changes radically and the above laws become completely invalid.

The following table lists data on several bright main-sequence stars:

Example star	**spectral class**	**temp.** (K)	**luminosity** (L_{sun})	**radius** (R_{sun})	**mass** (M_{sun})	**lifetime** (years)	**post-MS evolution**
Meissa	O	36000	80000	7.3	**	**	
Regulus	B	12000	240	3.6			
Sirius	A	9300	23	1.8			
Procyon	F	6500	6.8*	2.1*			
Sun	G	5800	1	1	1	10 billion	red giant → white dwarf
Eps. Eridani	K	5070	0.27	0.68			
Proxima Cen.	M	3070	0.0018	0.15	**	**	

Notes:
* Procyon is at the end of its main sequence life and is unusually bright and large for a main-sequence F-star.
** The mass-luminosity relation is particularly tenuous for very luminous and very faint stars.

1. Plot these seven stars on a temperature-luminosity diagram on the nearest board. (You don't have to be perfectly accurate; just show the general trend.) Remember that the temp. axis goes backwards.

2. Calculate the **mass** and total **lifetime** of one of these stars and fill this entries in the table. Make sure to translate the lifetime to years. (You may do the other stars if you have extra time.)

3. Use the flowchart on the handout from last time to figure out how each star will evolve once it leaves the main-sequence; add a short description of this to the final column of the table.

4. Suppose you are a member of a "creator race" of aliens, looking to seed long-lived civilizations throughout the galaxy. Based purely on lifetime considerations, what kind of star is best for this purpose?

5. The star Betelgeuse has a temperature of 3000 K and a luminosity of 55000 L_{sun}. Can we infer its mass and/or lifetime using the mass-luminosity relation? (If so, what is it? If not, why not?)

6. Based purely on the information above, can we tell which of these stars is oldest?

Original worksheet by D. Perley