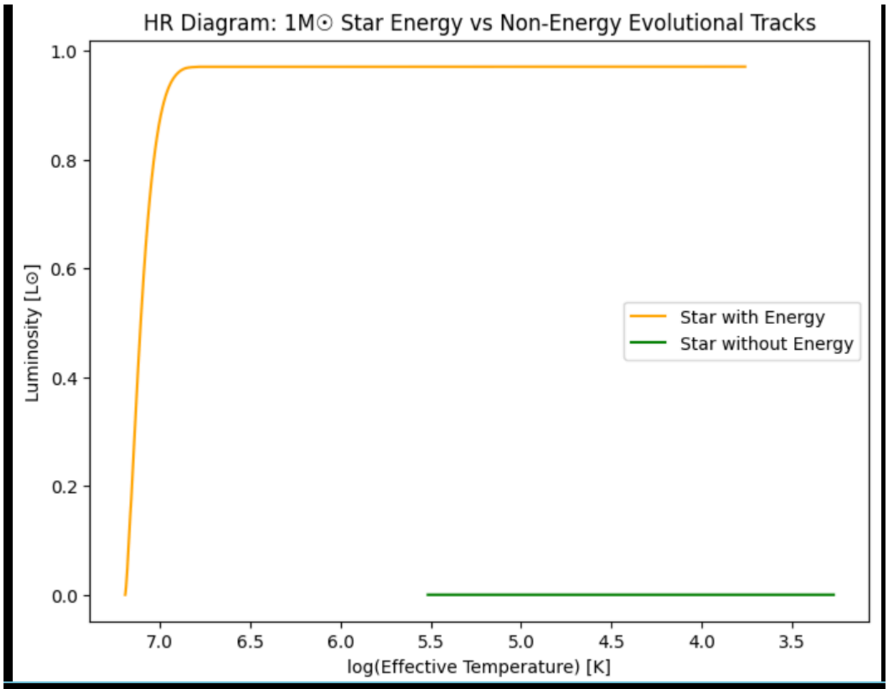
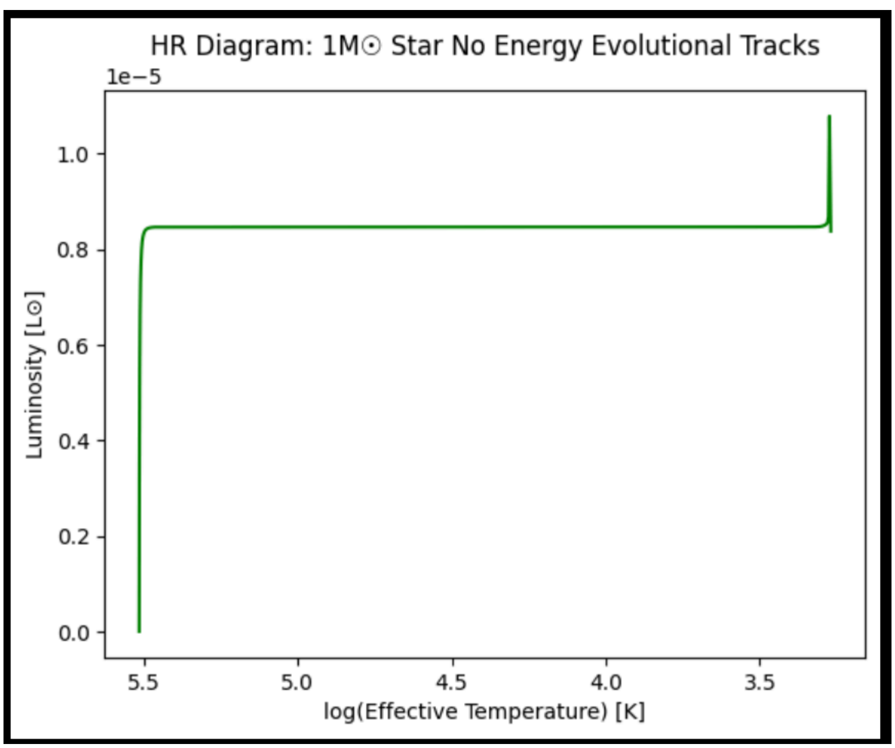
First, here are my 2 graphs representing the 1 solar mass star simulation with and without energy. The first graph contains both of the stars' evolution for comparison, while the second graph shows the evolution track of the no-energy star in greater detail:

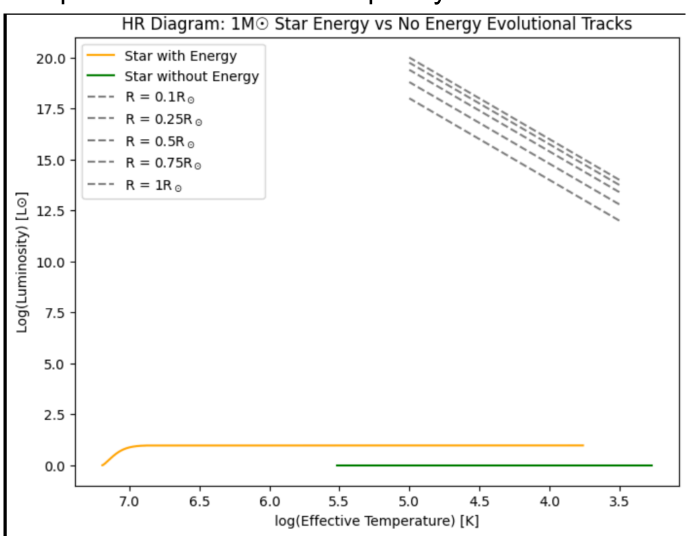




Now, according to the graphs I made, I will answer the questions below:

- Which agrees better with the observation of the real Sun at the Earth's age?
- What is its radius and how does it compare to the measured $R_\odot$? (**hint**: you can plot the lines at constant radius on the HRD, or read the outermost radius from the last profile*.data file you saved)
- What is the average density of the model without energy generation? (an order of magnitude estimate is sufficient for the purpose).

The star with energy definitely agrees better with the observation of the real Sun at the Earth's age. The star without energy doesn't even reach 1 solar luminosity in its lifetime. It got much dimmer and less energetic. The no-energy star is also a bit cooler than the energy star, although I would expect a larger difference in temperature since there is no energy to fuel the burning so that is quite a surprise for me. Both stars have similar evolutionary tracks. Their luminosity increases exponentially from the beginning of their lifetime (although these 2 increase more like a natural log function) and the luminosity becomes stable at their main-sequence state. However, it seems like the no-energy star has already reached the end of its lifetime demonstrated by the peak at the end of the graph. So it shows that without energy, the star also collapses on itself and dies quickly as well.



This graph represents how much of a failure I am by showing my pathetic attempt at plotting the constant radius lines on the HRD. Therefore I will just read the outermost radius from the data set. For the energy star, the radius reaches 0.995845 solar radius, which is very close to the radius of the sun. For the no-energy star, however; the radius is only 0.028125 solar radius, which is way smaller than the energy star and the sun. I guess the no-energy star must not have enough nuclear fusion force to push the star outward against the gravitational force, resulting in it collapsing prematurely.

```python
# Calculate the average masss, radius, and density
average_mass = star_irr['mass'].mean()
average_radius = star_irr['radius'].mean()
average_density = average_mass / ((4/3)* np.pi * average_radius**3)

# Print the results
print(f"Average Mass: {average_mass}")
print(f"Average Radius: {average_radius}")
print(f"Average Density: {average_density}")
```

6] ✓ 0.0s

```
Average Mass: 0.8005709032042172
Average Radius: 0.02231723235180751
Average Density: 17194.52517021923
```

I calculated the average density of the no-energy star by taking its average mass and radius. Since the unit for mass and radius is solar mass/radius, I think the unit of this density will also be solar density as well. And if this really is the case, this star is surprisingly dense. I did expect it to be dense of course since it collapsed on itself super quickly, but I did not expect it to be 17 thousand times denser than the sun! And that is a quite surprising result.