Index Card, Oct. 18

Group Activity: Print names and EIDs on the lined side of the card and put your response on the same side.

> As seen from the outside, a pre-Main Sequence star and an aging Red Giant look similar: both have large radii and cool surface temperatures.
>
> In what ways are they different from each other? Name at least three ways in which they differ, but include as many as you (as a group) can think of.

On the following slides, red font indicates errors or misunderstandings; black for answers/clarifications.

Differences: Composition

- "The Pre-Main Sequence star still has H in its core; the Red Giant has already converted its H to He."
- This is correct but only with the qualification that the RG has no more H ***in its core***.
- "The protostar is 75% H, Red Giant is 100% He." Again, only in the core. The surface of the Red Giant is still 75% H because it has not undergone fusion.
- Some people just said "composition." This is not sufficiently complete. On a quiz or exam, you would have to state what the difference in composition *is*.

Misunderstandings: Composition

- "Their spectra are different; the pre-MS star will not have as much helium [as the RG]." This is true, but this difference in composition applies ***only in the core***, where H fusion has or will convert the initial H into He. Material from this processed region *is not seen* at the star's surface (at this stage) because the energy flowing from the center is carried only by photons, in at least some of the intervening layers.
- "The RG fuses other stuff than He." No, when a lower-mass star becomes a red giant, it is not even fusing He yet, let alone heavier nuclei.

Differences: Energy Source

- "The Pre-Main Sequence star has not yet begun nuclear fusion … [it] is powered by gravity." Yes.
- "Protostars shrink due to gravitational potential energy." They shrink due to gravitational ***force***.
- "Nuclear fusion occurs in the Red Giant." Yes, but what reaction, and where? A Red Giant fuses H in a shell around the "burned-out" He core.
- "Helium is fused to carbon in Red Giants." The video implied so, but it's not quite correct. Stars that fuse He to C in the core are *horizontal branch* stars.
- Just listing "energy source" is an insufficient response.

Differences: Expansion vs. Contraction

- "Gravity outweighs outward pressure in a protostar, so it contracts, unlike the Red Giant, whose surface is expanding." Yes, the surface of the Red Giant expands, but in fact its core is contracting, and this actually supplies much of the star's luminosity. There is fusion in a shell around the core, but that happens only because the contracting core produces energy that heats the H in the shell to fusion temperatures.
- "The core of the pre-MS star is expanding …" No! Where did you get this from? The *entire* pre-MS star is contracting; it's still in the process of forming.

Differences: Track in the HR Diagram

- "The pre-MS star is moving towards the Main Sequence; the Red Giant is moving away from it." Yes, they are moving in opposite directions, though along a rather similar "track" in the HR Diagram.
- During the stages of a star's life when gravity provides at least some of its energy, it tends to have low surface temperature, large radius and high luminosity, and lies above and to the right of the Main Sequence. We call it a "protostar" before it reaches the Main Sequence, and say it is in one of the "giant" stages if it is post-Main Sequence.

Misunderstandings & Confusions

- "The pre-MS star is cooling down, the RG is heating up." No, the entire pre-MS star is heating up.
- "They have different masses." Not necessarily.
- "Red giants are denser." Their ***cores*** are very dense, but their outer layers have rather low densities.
- "They have different luminosities." It depends on where along the evolutionary "track" in the HR diagram the star is. There is a region of overlap.
- "The RG is cooler." No. It depends on where it is along the track, but generally protostars are cooler.

Misunderstandings & Confusions

- Some students seemed to mix up different life stages. They either confused the pre-MS star with a Main Sequence star, or the red giant with a white dwarf:
- "Activity slows down." You seem to be thinking of red dwarfs, which are low-mass Main Sequence stars.
- "Pre-MS stars have the potential to live longer." The pre-MS phase is actually very short.
- "One is a protostar, the other a retired star." In the video, Alex Fillipenko referred to white dwarfs as "retired stars." A red giant is definitely *not* retired, it is generating energy multiple ways and is evolving!