Announcements

- **Reading quiz.** There is no reading quiz due for tonight, Tuesday March 25. The next one is assigned for this week’s reading (see assignment below), and is due in two weeks (i.e., the Tuesday after Spring Break (April 8) at 11:55 PM. It will become available to take at the textbook website at 12:05 AM Wednesday, March 26.

**Reading Guide and Homework Assignment**

(Week #10 On-Line Reading Quiz Due: Tuesday, April 8, 11:55 PM)

This week we finally tackle the deaths of stars, and experience the full fury of gravitational collapse. This is all being done to provide an answer to the question: What happens when the fuel runs out in a star? Note that occasionally, in the text, you will run across a term that we briefly mentioned very early in the course, but have abstained from mentioning since: galaxy. We shall discuss galaxies a lot in the future but for now, to help you through the reading, just consider a galaxy to be a large assemblage of millions to hundreds of billions. It turns out that stars are not randomly placed throughout the universe: they are grouped together into individual galaxies. We, ourselves, live in just such a galaxy, the Milky Way. If you want a quick refresher on this terminology, go back to the Prologue, reread pages 7 – 15, and retake the “Grand Tour of the Heavens” through which you were introduced to this course.

1. **Text — Sections 13.4.3 and 13.4.4: Mass Loss from Giant Stars and Cosmic Recycling.**
   Read here about the last phase of existence for stars that are born with less than about 8 times the mass of the Sun. Bottom line: These stars swell up to become giant stars, and push out into the interstellar medium a substantial amount of their gas, forming beautiful planetary nebulae. (Note that the reading from the first parts of Chapter 13, on the evolution of main-sequence stars, is optional; again, we covered the essential bits of it in class.)

2. **Text — Sections 13.5.1 and 13.5.3: The Evolution of More Massive Stars: Making New Elements and Approaching Death.**
   Here you read about the last stages of life for those rare stars that are born with a mass greater than 8 times the mass of our Sun. Be sure to read the introduction to these sections, beginning on p. 301 of the text.

3. On-line tutorial: On the “Week10_tutorial” section of the textbook website, look (again) at the Active Figure called “Stellar Evolution of High and Low Mass Stars”. We began this week’s lectures with a reprise of this animation; if you haven’t personally worked with it yet, please do so now!

   This reading starts us out by describing the comparatively peaceful deaths of low-mass stars to the strange end-point known as a white-dwarf. A key point here is that all stars with masses somewhat less than 8 $M_\text{Sun}$ (i.e., less than 8 times the mass of the Sun) find a way to lose enough mass during their lives so that they wind up with $\leq 1.4 M_\text{Sun}$ at the end of their lives (i.e., less than the Chandrasekhar limit). As you read these sections, you will run across a term that comes from sections of the book that we have not covered in detail: The “H-R Diagram” (p. 316 first paragraph, as well as Figure 14.2). For our purposes, this is just a fancy way of referring to a plot of the luminosity of a star vs. its surface temperature, so that you can see at a glance how a star will evolve during its life in these fundamental parameters. We did not work with the H-R diagram in this class, and thus you are not responsible for knowing what one is. That said, you should be able to describe qualitatively what is being shown to you graphically in Figure 14.2.

5. **Text — Chapter 9, Section 9.4.4: The White Dwarfs.**
   Dip back into chapter 9 for a brief reading on the discovery of the first white dwarf, Sirius B.

Here we finally take on the death of massive stars. Remember, the key thing is that the formation of iron in the core of a star represents a point of no return: further fusion into heavier elements does not *produce* energy, it *requires* it. Thus, once that iron core is built up and a critical density is reached, the core of the star is doomed to collapse — gravity wins in the end! Explaining exactly how this collapse is turned into an explosion remains a challenge that is at the forefront of supernova research; §14.2.3 paints a rather more confident picture of our present degree of understanding than is probably justified — we shall discuss the remaining uncertainties in class a bit. Note that in Table 14.1, you’ll see a term that we haven’t discussed in class: “Brown Dwarf”. In case you’re curious (you’re not responsible for knowing what one is), it’s the kind of object that results from a ball of gas that begins life with between about 1% – 8% the mass of our sun — not quite a star, but different from a planet.

Note that in the final section of §14.2, §14.2.4, you are only responsible for the first 3 paragraphs on p. 320, which concern the forging of elements heavier than iron during a core-collapse supernova. The rest of the section discusses “cosmic rays” and their role in causing biological mutations, a subject that we’re not covering in class (but is interesting, nonetheless!).

7. **On-line tutorial:** On the “Week10_tutorial” section of the textbook website, look at the *Active Figure* called “End States of Stars”. This is a useful figure that reviews the lives and deaths of stars spanning a broad range of possible initial masses.

8. **On-line tutorial:** On the “Week10_tutorial” section of the textbook website, look at the *Active Figure* called “Future of the Sun”. This gives the future evolution of the Sun from the perspective of an Earthling (or Martian, if you desire). You see that Earth’s temperature increases steadily over the next 4.6 billion years, after which our Sun becomes a white dwarf star, and Earth’s temperature declines rapidly.

9. **Text — Chapter 14: Section 14.3.1: Supernova 1987A.**

Read here a discussion of the closest supernova observed by humans since the time of Johannes Kepler: SN 1987A. Observations of this nearby supernova allowed astronomers to confirm that many of their theoretical ideas about the core-collapse process were correct.

10. **On-line reading quiz (Due: 11:55 PM, Tuesday, April 8):** Take this week’s *reading quiz* by clicking on the “Week10_quiz” assignment at the on-line textbook web-site. The Reading Quiz will become available to you at 12:05 AM, Wednesday, March 26. It consists of only 5 multiple choice questions. **You must complete this on-line quiz by 11:55 PM Tuesday, April 8.** As always, you may take the quiz twice.

(A supernova graces the cover of Time Magazine, in 1987.)