Answers to Questions for study VII

Ward and Brownlee, *The Life and Death of the Planet Earth*

1. Define galaxy and solar system, and specifically address which one describes a bigger thing. Why won’t a galactic collision, as hypothesized, necessarily affect our solar system?

A galaxy is a group of stars held together by mutual gravitational attraction, circling a center point that may or may not contain matter (see the next question). A solar system is the material (planets, asteroids, dust, gas, comets) that orbit a particular star, clearly much smaller than a galaxy. Because of the mind-boggling large distance between stars (light years, remember?) the likelihood of collision with another star in a colliding galaxy is vanishingly small; even a “close encounter” close enough to gravitationally affect us is unlikely.

2. My goodness! There’s a black hole with a mass of two million times our Sun at the center of the Milky Way Galaxy (ours). Why aren’t we being sucked straight into it, if it’s so large (this is one “ending” you don’t have to worry about)? (Black holes, as you might recall, are the final stage of a massive star’s life; the galactic center black hole did not form from the collapse of a single star. No one quite knows how such a large black hole might form.)

Because we (that is, the Sun and its solar system) are in orbit around it. This means that we are going fast enough around the center to avoid falling into the center directly. (There is some concern, however, that we may be spiraling in toward the center).

3. The implications of this page are profound: what do the comments of this page suggest about the size a star should be if any orbiting planet were to have animal life? Does this increase or decrease the chance of finding ETs to talk to “out there”?

The star should not be much bigger than the Sun. In order to have animal life, a certain minimum length of time is required for evolution to make these complex organisms. Therefore the star must last at least that long, but stars larger than the Sun have shorter lifetimes. Thus, the star cannot be much larger than the Sun.

4. It would be neat to be part of a supernova. However, it seems like that will not happen; the Sun is not massive enough, according to the book. Why is there a minimum size limit for a star to go supernova? Find an astronomy textbook or website that will tell you the answer and cite the source.

There is a minimum size for a supernova because the core of the star must be compressed to such a great degree as to create neutrons. It is the rebound of the outer layers of the star off of the incompressible neutron material at the center of the star undergoing gravitational collapse that creates the supernova. The astronomy textbook *Voyages Through the Universe*, 3rd edition, by Fraknoi, Morrison and Wolff, on page 495 gives a table that shows a star with an initial mass of 12 solar masses or greater ending up as a supernova. It also shows that stars with less than 12 solar masses initial mass leaving white dwarf stars (no supernova) “because the star’s mass is
relatively low, it cannot push the temperature inside high enough to being another round of fusion” which is necessary to begin a supernova.

5. (pages 162 and 163) How does the moon literally end? How does the Earth end?

The Moon will end by spiralling into the Earth and colliding when the density of matter gets higher (causing greater drag) in our vicinity of interplanetary space due to the Sun reaching its red giant stage. The Earth may or may not end by being engulfed by the Sun when it reaches its red giant stage. If it is engulfed, then the Earth is vaporizing. If it is not, then the surface will melt and it might as well be the end.

6. (page 168) An English question: The authors mention the book *On the Beach* by Nevil Shute. It is a fascinating look at the consequences on a small group of humans that survives an all-out nuclear war. We probably should have assigned this book as part of the reading for the course. Find any source (including your classmates who have read it already) and tell me how the novel ends (I mean the plot, not the last words). (As a side point, absolutely do not rent the movie – it makes this topic boring).

Everyone dies — either by suicide or by radiation poisoning. C’mon, how did you think it would end?

7. (pages 169 through 173; Davies, pages 1 and 2) Excellent descriptions of the consequences of a comet striking the Earth. But why a comet? (That’s a rhetorical question). In fact, they point out that it was a ten-kilometer-wide asteroid that caused the dinosaurs to go extinct. What’s the difference between a comet and an asteroid? (That’s a real question). Explain if an asteroid impact or a comet impact is more devastating. Hint: see http://news.nationalgeographic.com/news/2003/01/0128_030128_comets.html

A comet is made of (mostly) ice (dry ice or water ice); an asteroid is made of (mostly) rock. A comet generally has an oval (eccentric) orbit, which allows it to develop a tail of streaming ionized particles near the Sun; an asteroid generally has a circular orbit between the orbits of Mars and Jupiter.

Both types of impact can be devastating. Asteroids tend to be heavier for the same size, due to their density, or, in fact, are just more massive than comets. Comets, on the other hand, are faster upon impact. Both characteristics (mass and speed) are critical in calculating the energy of an impact.

8. (pages 169 through 173; Davies, pages 1 and 2) Apart from being a longer account, what additional effects of cometary impact do Ward and Brownlee note that Davies does not? Describe at least four similarities between either account of a comet impact and the description given in Revelation 16:18-21; might it be reasonable to conclude that the writer(s) of Revelation may have seen or have heard of a tale of an impact?

Ward and Brownlee add the firestorms that would sweep the region of impact, the dust cloud that caused temperatures to plummet for a year, the acidic rain that would corrode skin, fur and hair.

In Revelation, the author(s) note(s) the “flashes of lightning, rumblings, peals of thunder, and a severe earthquake.” Moreover, cities collapse. “Every island fled away” could be interpreted as
being drowned by a tsunami. The “huge hailstones of about a hundred pounds each fell upon men” might be the rain of ejecta. One could believe that the writer(s) had heard of an earlier impact disaster.

9. (pages 174 and 175) Are gamma rays part of the electromagnetic spectrum, along with visible light and radio waves? If so, what makes them different from visible light and radio waves, and why can this difference be lethal?

Gamma rays are part of the electromagnetic spectrum, but of a higher energy wave than visible light or radio waves. This higher energy wave manifests itself in the penetrating power of the wave; gamma rays, unlike visible light or radio waves, can penetrate flesh and cause burns and other cellular damage to tissues far below the skin.

Davies, The Last Three Minutes

10. (chapter 4) What’s a supernova? What causes a star to “go supernova”? Will the Sun go supernova? How do we know the answer to the last question?

A supernova is the “death” of an old massive star. A star undergoes supernova when its ability to generate radiant energy (light and heat and high-energy particles) ends (typically when the core is composed of iron nuclei) and the star can no longer resist its own enormous gravitational force, and so the outer layers of the star collapses in on itself. The rebound of this collapsing material off of the iron core and its subsequent ejection into space is the supernova. The Sun will not go supernova because a) every star we have seen supernova has been a star more massive than the Sun and b) a model proposed by Chandrasekhar suggests that stars with at least 1.44 times the mass of the Sun are the only ones that can undergo supernova.