YOUR NAME: _____ Section: _____

Bill Gates' Great Great Grand-daughter's Honeymoon Trip: The 10 Tourist Wonders of the Universe

Astronomy Lab by Andrew Fraknoi *(Foothill College)*

Your group is a travel agency in the far future, when travel faster than the speed of light is not only possible, but common. (Your instructor doesn't think this is all that likely, but we are going to assume it so we can have some fun with this lab.) You are approached by a very wealthy young woman, who wants you to plan the honeymoon tour of a lifetime for her. Money is no object and safety will be taken care of by shielding the spacecraft in ways we can't even imagine today.

Using Hubble Space Telescope images, please select 10 visually and astronomically interesting places for the couple to visit. You don't need to be able to land to take in each sight; some you might just look at from space. Each place must have a science reason it is interesting; it can't just be that the place is pretty or colorful. Science reasons can include that a place is the biggest of its kind, that it's unique, the first to be discovered, or that it reveals something really important about the way the universe works. For example, if you select the Crab Nebula, don't just say you picked it because it has great colors or because it looks eerie, but (briefly) explain why supernovae and their remnants are important, and what makes the Crab an important example. You can find an index of Hubble images at: http://hubblesite.org/newscenter/archive/browse/images/

Your lab group will report to a symposium of travel agencies that we will hold toward the end of the lab. Only the top 3 tour plans will be forwarded to the client; but the winning agency could become rich and famous, so work hard.

1. Tourist Sight: _____

   Website: _____

   Justification: _____

   _____

   _____

   _____

2. Tourist Sight: _____

   Website: _____

   Justification: _____

   _____

   _____

   _____

3. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

4. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

5. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

6. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

7. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

8. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

9. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

10. Tourist Sight: _____

Website: _____

Justification: _____

_____

_____

_____

Notes For Instructors

Before You Start:

- At our college this lab takes about 2.5 hours to do fully, particularly if you have discussion (a symposium, where groups present examples of their work) at the end.
- Groups consist of 3 to 4 students at a computer. No student is allowed to work alone, since much of the benefit comes from sharing information and having a spirited discussion.
- I find it useful to put the web site: http://hubblesite.org/newscenter/archive/browse/images/ on each computer ahead of time. Some students may need to review the meaning of the categories into which the images are organized on this most useful page.
- It's good to remind students of the components of each Hubble news release: not only are there images and captions, but there are often pages of fast facts, background information, animations, etc.
- I encourage students to spend at least 20 minutes before they start writing on the lab sheet just trying out ideas, making a preliminary list, putting down some notes, etc.
- The lab is "open everything" -- they can use their notes, their textbook, or other web sites
- In introducing the lab, I emphasize that just about anybody can find 10 pretty Hubble pictures and write down the URL; most of their grade will depend on the justification they give for selecting a particular tourist attraction. A number of groups come up with cute explanations, such as selecting the Ring Nebula because it reminds the couple of the rings they just exchanged. While I encourage such creativity, I always remind them that the science reasons are the ones that count.
- Among the ground rules I set is that, if at all possible, students should include only one example of each type of object: so only one supernova remnant, only one red giant, only one region of star formation, only one solar system moon, etc.

Grading Rubric

- There are, of course, no right answers for this lab exercise. Unless the student disregards the instructions, or doesn't take the exercise seriously, I give credit for any reasonable choice of tourist destinations.
- With each of the ten answers worth ten points, I give two points for the selection of a reasonable tourist sight, one point for getting the URL of the image correct, and seven points for the justification.
- In the justification, I look for answers that explain what the object is, why the selected object is part of an important class and why it is representative of or a special member of that class. So, for example, a good answer about the Crab Nebula should include:
  a. The fact that it is a supernova remnant;
  b. Why supernovae are an important stage in stellar evolution (they are the last event in the life of a massive star, they recycle the elements stars make, etc.); and
  c. Why the Crab Nebula is an important example of its class (it's arguably the best studied supernova remnant, the first one in which a pulsar was found, one whose explosion was recorded in human history, etc.)
- See the next pages for a sample answer sheet of some informative and humorous justifications.

Sample of a Completed Answer Sheet for:
Bill Gates' Great-Great Granddaughter's Honeymoon Trip:
The 10 Tourist Wonders of the Universe
by Andrew Fraknoi *(Foothill College)*

1. Tourist Sight: The Planet Saturn and Its Rings

Website: http://hubblesite.org/newscenter/archive/releases/2001/15/image/a/

Justification: Saturn is the second largest giant planet in our solar system, and a beautiful example of the class of planets which are made mostly of liquid and gas. While all four giant planets in our solar system have rings, only Saturn has a spectacular ring system worthy of any tour's visit. The whole ring system is so large that, if we placed it next to the Earth, it would stretch almost to the Moon. In the ring system, there are many thousands of smaller structures (ringlets) and a host of small moons. Understanding how the countless small chunks of ice that make up the rings interact with each other and the moons inside and near them is a major challenge to astronomers. How ring chunks become organized into denser "crest" and less dense "troughs" helps astronomers understand the interactions of other organized systems in the universe, such as the arms of spiral galaxies. (And, of course, seeing rings is very appropriate for our honeymoon couple after their recent wedding ceremony.)

2. Tourist Sight: Eris, The Largest Known Dwarf Planet

Website: http://hubblesite.org/newscenter/archive/releases/2007/24/image/c/

Justification: Eris is the largest of the dwarf planets in our solar system discovered so far, even larger than Pluto. Dwarf planets are a population of objects in our home system, consisting of smaller (but still round) worlds which are too small to have cleared out their immediate neighborhoods. There may be many others beyond Neptune which have not yet been discovered (although many others will likely be known by the time our couple takes its tour). Eris is part of the Kuiper Belt, a region which also includes many smaller icy chunks. (Eris is named after the goddess of discord in Greek mythology, but our honeymoon couple is much too much in love to worry about that concept.)

3. Tourist Sight: The Orion Nebula, an interesting, relatively nearby star-formation region

Website: http://hubblesite.org/newscenter/archive/releases/2006/01/image/a/

Justification: This region of star birth, one of the closest and best studied we know, shows many young stars and dusty disks that are star systems in the process of forming. The visible nebula is just a small "pimple" on a much larger, colder (and invisible) cloud of cosmic raw material, through which a wave of star birth is passing. Our own solar system was probably born, about 5 billion years ago, in the same way as the new stars we see in the Orion Nebula. (The honeymoon couple's parents wanted us to include a tourist sight that referred to birth as a subtle hint to the newlyweds that they were looking forward to being grand-parents.)

4. Tourist Sight: Betelgeuse, a Red Giant Star

Website: http://hubblesite.org/newscenter/archive/releases/1996/04/image/a/

Justification: Toward the end of its life, every star goes through an unstable period when it swells up into a huge star, cooler than it used to be, called a red giant. Our own Sun is expected to become such a red giant in about 5 to 6 billion years. Betelgeuse is a well-known and much studied example of a red giant and the first star beyond the Sun for which astronomers actually got an image which showed the stars as a disk and not just as a point. If Betelgeuse were put into our solar system as a replacement for the Sun, it would reach almost to the orbit of Jupiter. (Since the hearts of the honeymoon couple are swelling with love, we thought they would enjoy seeing a star that has swelled up too.)

5. Tourist Sight: The Ring Nebula, the last gasp of a dying star

Website: http://hubblesite.org/newscenter/archive/releases/1999/01/image/a/

Justification: At the end of its life, every star that resembles the Sun undergoes a last period of unstable behavior (a kind of last gasp before dying). The star expels one or more outer layers before it starts to collapse into the "star corpse" astronomers call a white dwarf. Early observers mistakenly called the expelled shell of such a dying star a "planetary nebula", and, unfortunately, the name has stuck, even though this nebula has nothing to do with planets. Our own Sun is expected to produce just such a nebula before it dies. The Ring Nebula is a well-known example of a star's last gasp. While it looks like a ring from Earth, it probably would look like a barrel of glowing atoms and dust from nearby. (And, after all, the honeymoon couple is supposed to be having a barrel of fun on their trip.)

6. Tourist Sight: Sirius B, a White Dwarf Star

Website: http://hubblesite.org/newscenter/archive/releases/2005/36/image/a/

Justification: When stars like the Sun (stars of relatively lower mass) die, they become extremely compressed "star corpses" called white dwarfs -- very small, but very hot. Such a white dwarf happens to orbit Sirius, the star that appears brightest in our skies, and is given the very boring name, Sirius B. Still, such a tiny white dwarf is an impressive thing. If the couple were to land (strongly not advised) they would weigh about one million times their Earth weight and that would be the end of their trip. This is a sight best viewed from afar, but with a contemplation of the fact that bec0ming a white dwarf will be the ultimate fate of our Sun too. (The inner core of each white dwarf consists of carbon, fused in the last years of the star's life. But it is carbon under enormous pressure, whose structure resembles that of diamond. As the bride and groom look at their engagement ring, they will enjoy comparing it to the great diamond-like structure inside Sirius B.)

7. Tourist Sight: The Crab Nebula, Remnant of An Exploded Star

Website: http://hubblesite.org/newscenter/archive/releases/2005/37/image/a/

Justification: Massive stars end their lives in huge explosions that astronomers call supernovae. As much as 90% of the star's material can be thrown off during the explosion and, in the process, new (heavier) elements are made, and then distributed at high speed into the Galaxy. In many ways, life on Earth owes its existence to supernovae and the fact that they "recycle" the material of early generations of stars and make them available to form new stars and planets enriched by their elements. The Crab Nebula is the remnant of a supernova whose light reached the Earth in the summer of 1054 AD. Even though it is about 6500 light-years away, it was so bright then that it could be seen in the daytime. The Crab Nebula was also the first supernova remnant in which astronomers discovered a pulsar (short for pulsating star) which flashes 30 times a second, and is evidence that inside the nebula the last remains of the star that exploded is still spinning energetically. (The pulsar is like a speeded-up heartbeat, which is just what the newlyweds feel when they look at each other adoringly.)

8. Tourist Sight: Fomalhaut, the first star whose planet we photographed in visible light

Website: http://hubblesite.org/newscenter/archive/releases/2008/39/image/a/_____

Justification: Being fans of astronomy, our honeymoon couple knows that one of the most important discoveries in modern astronomy has been the discovery of planets around other stars. Although, at the time in the future that our trip is happening, millions of planets are likely known in orbit around the stars of our Galaxy, for sentimental reasons, the couple will visit the first planet ever photographed in visible light, way back in 2004 and 2006, with that old Hubble Telescope that the couple learned about in history class. Fomalhaut is a star located about 25 light-years away and its planet is not likely to harbor any kind of life as we know it. The planet takes 872 Earth years to revolve around the star, and it is about 10 times further from Fomalhaut as Saturn is from the Sun. It is in part because the planet is so far from its star that it is not completely lost in the star's glare, and could be distinguished from Earth.

9. Tourist Sight: Omega Centauri, the largest known globular cluster of stars

Website: http://hubblesite.org/newscenter/archive/releases/2008/14/image/a/

Justification: Stars in a galaxy are sometimes organized in larger groups called star clusters, and the biggest and oldest of these groups are called globular clusters. These huge clusters are like "fossils," giving us hints about the early history of the Galaxy. Omega Centauri is the largest of these, containing as many as 10 million stars. It is located about 17,000 light-years from us. Stars at its core are so crowded together; some may be as little as a tenth of a light-year apart. (For stars, that are getting really "cozy," a concept the honeymoon couple really likes to identify with.)

10. Tourist Sight: Galaxy NCC1300

Website: http://hubblesite.org/newscenter/archive/releases/2005/01/image/a/

Justification: For their last trip before returning home, our couple wants to visit a galaxy, and this one is their favorite. It is a barred spiral shape, which resembles the Milky Way Galaxy in which we live (although the bar in NGC1300 is longer and more distinct than ours probably is.) This galaxy is also about the same size as the Milky Way and the couple wants to see a galaxy that looks like our own. NGC1300 lies about 69 million light-years away. Its center is quiet (not disturbed) indicating that it may have an inactive black hole or no black hole in the middle. (After all the excitement of the trip, our couple wants a peaceful last sight to finish off with.)