Top Ten Points from Class

1. Life needs complex chemistry, hence could not have started before stars produced elements heavier than helium, such as carbon, nitrogen, and oxygen.
2. Evolution as an established fact is that we see changes in organisms over time. Evolution as a theory is that variation in offspring means some will produce more children than others, which will inherit many of the characteristics of the progenitor. Variation itself comes from many sources, such as mutation and horizontal gene transfer, but is not directed towards a goal: evolution gropes blindly in many directions at once.
3. Life on Earth has tremendous variety. There are fundamental requirements about chemical components, energy, stability, and liquid water, but not everything needs oxygen or even sunlight. The first life on Earth may have been in the extremophile category. In addition, evolutionary surges have often occurred after mass extinctions, due to the new ecological niches that naturally open up.
4. If liquid water is essential, and if the only heat source comes from the host star, there is a relatively narrow band around a star that will allow liquid water to exist. However, examples such as Jupiter's moon Europa show that other energy sources (tidal heating in this case) can allow water to exist far outside the habitable zone.
5. In the inner Solar System, Mars is the best bet for currently having life. If so, that life is underground where liquid water might exist. Venus might have supported life in the past, but the odds are strongly against it now. In the outer Solar System, Jupiter's moon Europa has liquid water beneath many miles of ice. With likely geothermal vents, Europa is possibly the best bet for life in our Solar System outside Earth.
6. Our impact on the Earth is very substantial. Exponential growth of population (currently we increase at a rate of about 1% per year) will always overwhelm resources eventually, and space flight is far too expensive for us to solve our problems by leaving. A stable population and a shift to renewable resources are critical to our continued rise in technology.
7. Extrasolar planets are common, but because of limits on how we detect them the systems are much different from our own. However, the commonality of planets and presence of a couple in possible habitable zones suggests that planets capable of hosting life might be reasonably normal in the universe. The implications for communicative civilizations, however, depend on many other uncertain factors in the Drake equation.
8. Intelligence and indeed complex organisms developed late on Earth. What this means for intelligent life elsewhere is not clear; it could be very unusual or could be a natural consequence of intelligence being advantageous in many ecological niches. It is not clear

how other civilizations would communicate, but there is no reliable evidence that we have been visited.

9. Interstellar travel is extremely challenging given the distances involved. Since relativity prevents us from moving faster than the speed of light (and if we could we could also travel back in time), either we have to have very long trips or go close to the speed of light and take advantage of time dilation effects. Despite these difficulties, there has been plenty of time in the history of our galaxy for a civilization to occupy it entirely, so why are they not here?

10. If we were willing to spend a large fraction of the resources of the Earth, we could terraform Mars right now. Is it worth it, and would it be ethical? In the future we may be able to send robots ahead of us to terraform planets, so the planets are ready when colonists arrive.