12.842 / 12.301 Past and Present Climate
Fall 2008

12.842 Climate Physics and Chemistry
PALEOCLIMATE PROBLEM SET #1
Due Monday Oct. 6, 2008

1. Nucleosynthesis.
   (a) What percentage of nuclear matter in the universe is accounted for by H & He?
   (b) What is the reason for this?
   (c) Why is the abundance of Fe in the universe substantially higher than that of nearby elements in the Periodic Table?
   (d) What is origin of elements below Fe (mass # 56) in the Periodic Table?
   (e) What is origin of elements above Fe in the Periodic Table?

2. 'Faint Young Sun Paradox'.
   (a) What is the 'Faint Young Sun Paradox'?
   (b) What is the most likely solution to this paradox?

3. Origin of Life. Briefly discuss why it is so difficult to determine 'when life began'

4. Evolution of Atmospheric Oxygen.
   (a) Sketch the time evolution of atmospheric oxygen concentrations relative to present-day levels.
   (b) Briefly discuss three pieces of evidence leading to our understanding of the history of atmospheric oxygen concentrations and the age interval over which that evidence applies.
   (c) What biological process is believed to have resulted in the oxygenation of the atmosphere? Write the equation for that process.
   (d) What biological process is the primary sink for oxygen in the atmosphere and ocean? Write the equation for that process.
   (e) Why doesn't (d) exactly balance (c)?
   (f) Discuss one additional process that is believed to have contributed to the oxygenation of the atmosphere.

5. Carbon Isotope Systematics.
   You observe that the $\delta^{13}C$ (carbon isotopic ratio) of marine carbonates increased substantially at a time in the early Phanerozoic.
   (a) What do you conclude about the proportion of carbon that was buried as organic carbon relative to carbonate at that time?
   (b) What do you infer happened to atmospheric oxygen concentrations at that time?

6. Planetary radiation balance.
   (a) Describe each of the terms (σ, Teff, S, A) in the planetary radiation balance equation:
   $$\sigma T_{eff}^4 = S/4 * (1-A)$$
   (b) What is meant by the term "radiation balance" in this equation?
   (c) Why is S divided by four?
   (d) Why is A subtracted from one?
   (e) Provide reasonable values for T_{eff}, S, A today.
   (f) What is the observed difference between T_{eff} and surface temperature?
   (g) Why are surface temperature and T_{eff} different?