Honors Seminar 256 — cheat sheet for 9/20/2011 — Andrew Baker

Chyba & Sagan (1992)

You may skim over the contents of Box 1 (try at least to understand what the goal of the derivation is), but otherwise read the full paper. Key questions:

1. What are the basic candidate origins for the Earth's early organic compounds?
2. In any scientific investigation, there are many sources of uncertainty (possible experimental errors, assumptions that must be made in the absence of empirical evidence, etc.). What is the dominant source of uncertainty in these authors' assessment of where the Earth's early organic compounds came from? What are some of the other uncertainties?
3. What are the different kinds of bodies that can fall onto the Earth from space, and how do their properties determine the details of their fate?
4. How do observations of the surface of the Moon shed light on the early history of the Earth? Why can't we get equivalent information from studying the surface of the Earth?
5. Why are the dashed curves in Figures 1 and 2 described as "upper bounds," and why is the dotted curve in Figure 2 "especially poorly understood"?
6. How do these authors' assumptions differ from those made by Miller (and Urey) in the interpretation of early origin-of-life experiments?

Key terms:

- **ablation** = erosion of an object's surface (in the context of this paper, by the friction of the atmosphere).
- **amphiphilic** = adjective describing a molecule (like a phospholipid) that has both hydrophilic and hydrophobic components.
- **bolide** = a generic term to describe a very large impactor whose full nature is not known.
- **C-type** = adjective describing an asteroid that is carbonaceous (i.e., rich in carbon rather than silicon).
- **chondrite** = a type of meteorite containing *chondrules* (small, round, mineral grains that were once molten liquid).
- **fractionation** = separation of a mixture of substances into different constituents.
- **photodissociation continuum** = all photons (light) whose energy is high enough to break apart a particular molecule when absorbed.

- **Poynting-Robertson drag** = the effective "friction" that causes dust grains in orbit around a star to spiral slowly inward towards the star.
- **Prairie Network fireballs** = fireball (meteor-entering-atmosphere) events observed by the Prairie Meteorite Network, a set of 64 cameras at 16 stations in seven states operated by the Smithsonian Astrophysical Observatory from 1962 to 1975.
- **pyrolysis** = decomposition of organic compounds due to heat, in the absence of oxygen.
- **reducing atmosphere** = atmosphere whose composition favors chemical reactions leading to the gain of electrons by the atoms or molecules with which the atmosphere reacts.
- **siderophile** = adjective describing an element that bonds well with iron.
- **specific efficiency** = efficiency of a chemical process per unit mass and per unit energy.
- **superthermal hydrogen atom** = atom that acquires so much energy by absorbing a photon that its kinetic energy exceeds what would be expected given the temperature of the parcel of gas in which it is found.

Miller (1953)

In addition to this paper's scientific content, you may wish to consider the stylistic contrast between its prose ("an apparatus was built," "it is estimated," etc.) and the Chyba & Sagan review ("we employ a model lunar bombardment history," "we scale the IDP flux linearly," etc.). Key questions:

1. What assumptions does the author make in setting up (and interpreting the results of) his experiment?
2. Are their some aspects of his results that the author does not or cannot fully explain? Would you judge that this undermines the quality of the paper?
3. Why do you suppose that the author published this paper, despite the fact that "[a] more complete analysis... is now being performed and will be reported in detail shortly"?

Key terms:

- **ampholyte** = molecule that contains both acidic and basic components.
- **colloid** = a mixture of two substances in which one is evenly mixed or suspended in another.

- **paper chromatography** = a technique for identifying a substance based on its solubility in one or more solvents. A spot of the "mystery substance" is placed on a think sheet of chromatography paper, which is then hung vertically with its bottom edge immersed in a liquid solvent. As the solvent is absorbed by the paper and creeps upward, it will eventually encounter the "mystery substance" and (if it dissolves the "mystery substance") carry it along. The speed at which the mystery substance (or its consituents) moves upward depends on how it responds to the solvent and the paper. The paper can be dried, rotated by 90°, and placed in contact with another solvent to gain additional information.

- **turbidity** = cloudiness of a fluid.

Westheimer (1986)

Caveat lector: the journal in which this commentary was published swapped Figures 1 and 2, which you should keep in mind as you are reading the text. Key questions:

1. What is the distinction between an enzyme and a compound that undergoes a very rapid chemical reaction?

2. How do the papers of Cech et al. (1981) and Zaug & Cech (1986) relate to each other?

3. What generalization about enzymes does the work of Zaug & Cech (1986) disprove, and to what extent was this a surprise?

Key terms:

- **3′ and 5′** = the two directions along a strand of DNA or RNA, corresponding to the "three prime" and the "five prime" carbon atoms within the (deoxy)ribose sugar ring that is part of the nucleic acid's backbone. Since DNA and RNA in living organisms are always synthesized in the can be thought of as "upstream" and the 3′ direction as "downstream."

- **alkali** = in this context, a chemical base, which can break apart RNA but not DNA.

- **cleave** = to split a DNA or RNA strand at a particular location.

- **enthalpy of reaction** = the change in enthalpy (the energy that can be extracted from a system for useful work, at constant pressure and entropy) per unit mass that occurs when a particular chemical reaction takes place.

- **exon** = part of a DNA or RNA sequence that actually encodes the formation of a protein.

- **intron** = part of a DNA or RNA sequence that does *not* encode the formation of a protein.

- **oligonucleotide** = a DNA or RNA sequence of ≤ 20 bases.

- **residue** = the portion of a large molecule that is left over when an amino acid or nucleic acid is incorporated into chain via the removal of a water molecule.
- **restriction enzyme** = enzyme that can cut a DNA strand at a location marked by a particular base pair sequence.
- **tertiary structure** = the three-dimensional shape that a protein or other complex molecule takes after folding into its preferred configuration. A protein's *primary* structure is the sequence of amino acids that defines it.

Gilbert (1986)

Note that this paper was published only one week after Westheimer (1986), and in the same journal! Key questions:

1. The question of life's origin is often viewed as a "chicken and egg" problem, with the central question being whether metabolism preceded replication or vice-versa. How does this article propose to solve the problem?
2. The concept of an "RNA World" is credited to Gilbert in this article. How does his essay relate to previous work by others?
3. In an "RNA World," what mechanism does Gilbert postulate fills the same role that sex plays for today's living organisms, and why is this important?
4. How does Gilbert suggest that the transformation from "RNA World" to our current DNA, RNA, and protein biology occurred? How does natural selection figure in this process?
5. What property of DNA does Gilbert suggest was "inherited" from ancestral RNA molecules?