Honors Seminar 259 — cheat sheet for 9/15/2008 — Andrew Baker

For Sagan (1967), I've tried to aim for something closer to a reading guide than a cheat sheet per se; the "key questions" are ones that I hope will spur interesting discussion in class. In addition to the abstract, you should read §1, 2.1–2.3, 2.6, 3.1–3.3, 3.6, 3.8, and 4, which together total about 22 pages of text. (§3.4–3.5 are interesting but rather technical discussions of the likely prokaryotic precursors of today's eukaryotic organelles; §2.4–2.5 and 3.7 pertain to the origin of mitosis, flagella, and related cellular structures, a point on which the author's arguments in this paper are not widely accepted today.)

Abstract and Section 1

Key questions:

1. What is the distinction between "symbiosis" and "endosymbiosis"?
2. How does the author characterize the relationship between her analysis in this paper and work that has been done previously by other groups? How do you think scientific credit should be awarded in this case?

Key terms:

- **aerobic** = adjective describing an environment or process in which oxygen is present.
- **anaerobic** = adjective describing an environment or process lacking oxygen.
- **basal body** = the structure *inside* a cell constituting the base of a flagellum or (shorter) cilium that extends *outside* the cell. The author refers to "(9+2) basal bodies" because of the characteristic symmetry of these and similar structures in cross-section when viewed with a microscope.
- **flagellum** (plural flagella) = a long, filamentary structure that extends outside of a cell and allows it to move (e.g., the tail of a sperm cell).
- **mitosis** = the highly organized process in eukaryotes whereby the chromosomes in a parent cell's nucleus are duplicated and split into two daughter nuclei, immediately before the parent cell as a whole splits into two independent daughter cells.
- **organelle** = a structure within a cell that plays some role in the cell's function (and in many cases, is enclosed within its own membrane).
- **plastid** = a category of pigment-containing organelles that are found in plants and algae but not animals; the chloroplasts responsible for photosynthesis in plants are one type.
- **symbiosis** = any arrangement in which two organisms of different species live together in a close interaction. Depending on whether the interaction is helpful to one and harmful to the other, helpful to one and neutral to the other, or helpful to both, we refer to the symbiosis as parasitic, commensal, or mutualistic.

Sections 2.1–2.3 and 2.6

Key questions:

1. The early terran atmosphere is likely to have consisted primarily of N_2, CO_2, and water, with small amounts of H_2, CO, and methane (CH_4), and almost no oxygen (O_2). Oxygen began to build up as water molecules were split into oxygen and hydrogen atoms, of which the latter (being lighter) tended to escape into space. What relationship does this atmospheric evolution have to the origin of photosynthesis in living organisms?

2. How did the development of photosynthesis in turn affect the further evolution of the atmosphere? What selective (i.e., evolutionary) pressure did this evolution exert on other microbial life at the time?

3. Given that all eukaryotes contain mitochondria but not all contain plastids, what (if anything) does the endosymbiosis hypothesis imply about the order in which events occurred?

4. What changes to cells did the incorporation of mitochondria facilitate according to the endosymbiosis hypothesis?

5. In Figure 1, why don't the branches of the main "family tree" correspond exactly to the distribution of encircled letters (R, G, Y, and B)?

Key terms:

- **cistron** = minimum DNA segment required to produce a protein (i.e., a gene).
- **cytochrome** = a category of proteins used for electron transport in metabolism and found in mitochondria, chloroplasts, and some prokaryotes.
- **endoplasmic reticulum** = complex, membrane-like organelle in eukaryotic cells that contributes to protein folding and transport.
- **obligate** = adjective signifying that some property is *required* for survival.
- **phytoflagellate** = a category of protozoans equipped with flagella that are also photosynthetic.
- **polyploidy** = arrangement in which a cell has more than the (standard) two sets of homologous (matching) chromosomes.
- **porphyrin** = a category of organic compounds featuring central cavities that can be filled with metal ions; the protein hemoglobin includes porphyrins containing iron ions, while chlorophyll is a porphyrin containing a magnesium ion. Amont their other properties, porphyrins can absorb ultraviolet photons capable of causing damaging mutations to DNA.
- **respiration** = process by which a cell extracts energy from nutrients (in eukaryotes, this requires the deep involvement of mitochondria).

Sections 3.1–3.3, 3.6, and 3.8

Key questions:

1. How does the author justify her rank ordering (from most to least important) in Table 2 of the criteria for devising a "family tree" of life? Are phylogeny and taxonomy different words for the same thing?

2. Under what circumstances can endosymobiosis be partially or fully reversed?

3. The author makes a subtle but general argument at the end of §3.2 about interpreting the range of variation among related species in terms of when a particular trait first evolved. How exactly does the logic here work? (Consider the difference between the effects of selective pressure acting *now* and selective pressure acting a long time ago.)

4. What can happen if the rates of replication of DNA in a eukaryotic cell's nucleus and in its organelles are not roughly matched?

5. Imagining yourself sixty years into the future, which of your grandchildren will share your mitochondrial DNA?

6. Considering the general properties of symbiosis that are listed in §3.3, what types of observations would *disprove* the hypothesis that a particular organelle had an endosymbiotic origin?

7. If one accepts that the endosymbiosis hypothesis is true for mitochondria, is it still possible that the hypothesis is false for chloroplasts? How about vice-versa?

8. In §3.8, why does the author accuse Gibor & Granick (1964), a paper she praises elsewhere, for being "patently Lamarckian"?

Key terms:

- **anisogametic** = adjective describing fertilization in a sexually reproducing species when the female's germ cell is larger than the male's.
- **cytoplasmic heredity** = inheritance of DNA in organelles rather than in (nuclear) chromosomes (note that this process does *not* obey Mendel's laws, because the DNA need not come equally from both parents).
- **monophyletic** = adjective describing an evolutionary change that happened exactly once in the family tree of life.
- **phylogeny** = determination of how different species are related to each other.
- **taxonomy** = system for classifying how closely different species resemble each other.

Section 4

Key questions:

1. What similarities does the author predict will be found for the nuclear (chromosomal) and organelle DNA sequences, respectively, of different organisms?

2. Why does the author declare that "as in the past, future attempts to relate the various classes of algae to each other will be futile"?

3. Extrapolating beyond the data available to the author when she wrote this paper, can you speculate on the evolutionary history of certain species of algae whose choloroplasts are found to be enfolded in *multiple* membranes?