ASTR/GEOL-2040-001: Search for Life in the Universe
Homework #3 Due: Wednesday Sep 27, 2017

1. On its way to Jupiter, the Galileo spacecraft had a gravitational assist flyby of Earth in December 1990. Carl Sagan and collaborators used this opportunity to determine from Galileo's recordings alone whether there is life on Earth. Look at their paper in Nature, **365**, 715 (1993) [for a copy, see my temporary link on: `http://lcd-www.colorado.edu/~axbr9098/teach/ASTR_2040/material/`] to answer the following questions.

(i) How did Galileo detect O_2? [2pts]

(ii) What considerations did the authors make to arrive at the conclusion that the detection of O_2 does at least raise our suspicion about the presence of life? [2pts]

(iii) What value for the rate of injection of CH_4 do the authors estimate for the Earth. Why is the detection of CH_4 indicative of life on Earth? Hint: think of circumstances when it would not necessarily be indicative of life. [2pts]

(iv) In what part of the spectrum was N_2O detected? [2pts]

(v) Which biogenic and abiogenic mechanisms do the authors discuss to explain the presence of N_2O? [2pts]

The purpose of this exercise is to make you read a scientific article by a scientist whom you might have known only from his public outreach activities.

2. **Metabolic reactions**. Identify the energy source, the electron donor, the carbon source, and thus determine what kind of a life form would utilize this reaction. *Mark the correct parts with a circle and fill in the empty fields.*

In the reaction $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$, (no sunlight involved)

the energy comes from: (sunlight/molecules), so the relevant prefix is (photo/chemo) [2pts]

the electron donor is: ....., which is (organic/inorganic), so (organo/litho), [2pts]

and the carbon source is: ....., which is (organic/inorganic), so (hetero/auto), [2pts]

and so it is a: .....troph. [2pts]

3. **Disentangling origin of life questions on Mars.** Imagine that some time in the future, microbial life was detected in the soil of Mars, and that it is based on the same sort of DNA as life on Earth. Explain in more detail the four possible alternatives for the origin of that life, including (a) the possibility of independent developments of life on both bodies, (b) panspermia from outside the solar system, as well as (c) panspermia from Mars, and (d) contamination from Earth.

(i) Comment on the likelihood of the four scenarios (a)–(d). [4pts]

(ii) Suppose the handedness of the molecules in Martian life was opposite to that in terrestrial life. Discuss the implications for each of the four possibilities. [4pts]