Use of alternative enantiomers by life on Earth . Henry J. Sun, Desert Research Institute, 755 E. Flamingo Road, Las Vegas, NV 89119. henry.sun@dri.edu

In this presentation I summarize the work in my laboratory in the area of chiral biology. Initiated about two years ago, this work intends to address two related questions: 1) Given the presence of a small amount of D-amino acids in bacterial cell walls (peptidoglycans) and the fact that these structures are recalcitrant, what might the enantiomeric biosignature of a microbial community looke lit? and 2) because earth organisms are exclusively or nearly exclusively composed of L-amino acids and D-sugars, it has been widely assumed that only these enantiomers are used as nutrients by terrestrial organisms. Is this assumption true?

Our efforts on question #1 focus on endolithic microbial communities, a life form widely accepted as an analog to how microorganisms might survive on the surface of Mars. Data collected so far show that these communities contain, in addition to the expected L-amino acids, large quantities of D-enantiomers. The kinds of D-enantiomes are consistent with bacterial peptidoglycans, indicating that bacterial structural remnants accumulate among the living organisms. This finding is significant for chirality based life detection. Had we not had the *a pirori* knowledge about our samples, we would have concluded, incorrectly, that they contained remants of a past biota. This is because over geological timescales preserved L-amino acids can reversibly convert to D-form through abiotic racemization.

Our work on question #2 indicates that not all chiral substrates are used in a stereo specific manner. Sugars appear to be stereo specific. Select bacteria, archaea, and eukaryotic yeasts and fungi consumed D-glucose and D-xylose, but not L-glucose or L-xylose [1]. An example of this stereo specific consumption is shown in Fig. 1 for the fungus *Penicilium expansum*. We also tried to enrich for L-sugar users from soils using nutrient media that contain L-sugars as the sole carbon source. No L-users were found. The bacterium *Ochrobactrum anthropi* was previously claimed to be a L-glucose user. Our data contradicts that claim: it uses D-glucose, not L-glucose.

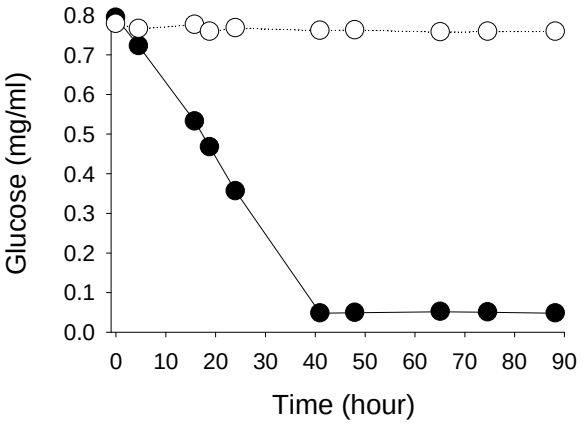

Figure 1. Consumption of D-glucose (filled symbol) and L-glucose (open symbol) added to a culture of *Penicilium expansum*.

Neither amino acids nor lactic acid are stereo specific. With few exceptions, studied microorganisms are capable of utilizing D- and L-enantiomers of these compounds. The only difference between the two forms is in the onset of their consumption. In the case of lactic acid, the D-enantiomer is the prefored form and its use starts first [2]. For amino acids, the reverse is true. Organisms prefer the L-form and start using it immediately upon addition. In contrast, the utilization of D-amino acids require a periof of preparation (Fig. 2). For both lactic acid and amino acids, we speculate that the induced activity of a racemase is responsible for the consumption of the alterative enantiomer.

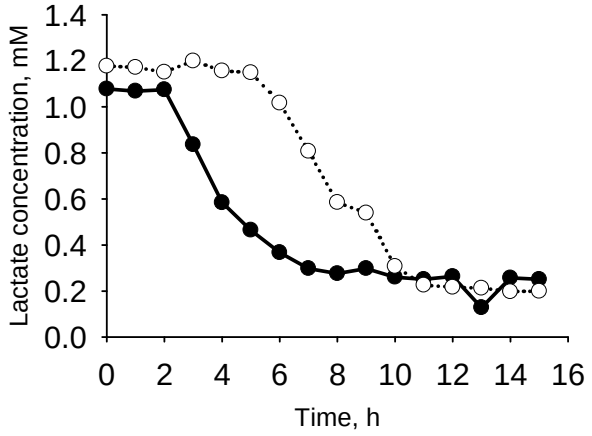

Figure 2. Consumption of D-lactate (closed symbol) and L-lactate (open symbol) added to a soil from the Atacma Desert.

These results have bearings on the use of the enantiomers as a means to detect metabolism. The Viking Labeled Release experiment showed that Martian surface soil is reactive [3]. When lactic acid, alanine, and other organics were added, they were converted to carbon dioxide. But whether this reactivity indicates the presence of living organisms or inorganic soil oxidants is a contentious point. It is thought that the debate can be settled by a chiral LR, where pure enantiomers are introduced separately. Biological activity is thought to consume only one enantiomer type, wheras abiotic mechanisms would destroy both. Our study indicates that a successful chiral LR would require a carefully selected list of biochemicals. More work is needed to determine if other chiral compounds have the desired stereospecificity to be useful for chiral LR.

1. Sun, H.J., et al., *Stereo-specific glucose consumption may be used to distinguish between chemical and biological reactivity on Mars: a preliminary test on Earth.* Astrobiology, 2009. **9**: p. 443-446.
2. Faegheh, M., G. Zhang, and H.J. Sun, *Imperfect asymmetry of life - Earth microbial communities prefer D-lactate but can use L-lactate also.* in review at Astrobiology.
3. Levin, G.V. and P.A. Straat, *Viking labeled release biology experiment: Interim results.* Science, 1976. **194**: p. 1322-1329.