THE UV ENVIROMNENT FOR PREBIOTIC CHEMISTRY. S. Ranjan[1] and D. Sasselov[2], [1]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, sranjan@cfa.harvard.edu [2]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, dsasselov@cfa.harvard.edu

Introduction: Ultraviolet (UV) light plays an important role in the chemistry of prebiotic molecules. UV photons are energetic enough to photolyze bonds, ionize electrons, or excite molecules. These effects can degrade biologically important molecules, acting as an environmental stressor [1]. However, this same property means that UV light is an ideal candidate as a source of energy for Miller-Urey style synthesis of prebiotic molecules [2] and UV light has been invoked to help explain prebiotic chemistry as diverse as the origin of chirality [3] the synthesis of amino acids [4] and the formation of ribonucleotides [5]. Due to the greater fractional output of the young Sun in the UV compared to the modern Sun [6] as well as the absence of biotic UV-shielding O2 and O3 in the prebiotic terrestrial atmosphere, UV light is expected to form a ubiquitous component of the prebiotic environment. Indeed, [7] estimate that for an ozone-free prebiotic atmosphere, UV light with λ<300 nm contributed three orders of magnitude more energy than electrical discharges or shockwaves to the surface of the early Earth. UV light was the most abundant source of energy available for prebiotic chemistry.

Many experimental studies of prebiotic chemistry have sought to include the effects of UV irradiation. Often this is accomplished by irradiating the reactants with UV light from sources such as UV lamps. Such lamps are safe, stable and affordable. However, their output is often characterized by narrowband emission at specific wavelengths: for example, mercury lamps with primary emission at 254 nm are commonly used as proxies for prebiotic solar UV input [8,9,10]. However, solar UV input is characterized by broadband emission. Many photoprocesses involving biological molecules are wavelength-dependent [11]. Hence, conclusions drawn from simulations conducted using monochromatic UV light may not hold true under more realistic conditions. In addition, solar UV input also shapes atmospheric photochemistry, which may impact the availability of reactants for some of these prebiotic pathways and the energy deposited at the surface.

In this work, we explore the impact of UV light on prebiotic chemistry and the implications for laboratory simulations. We consider effects including atmospheric absorption, attenuation by water, and stellar variability, to estimate the UV input as a function of wavelength in prebiotically important environments. We compare these estimates to the output of UV lamps, and discuss the implications for laboratory studies. We consider as case studies the ribonucleotide synthesis pathway of [5] and the sugar synthesis pathway of [12]. Irradiation by narrowband UV light from an Hg lamp formed an integral component of these studies: we explore their viability under more realistic UV input. Finally, we consider the constraints solar UV input places on the buildup of prebiotically important feedstock gasses like CH4 and HCN.

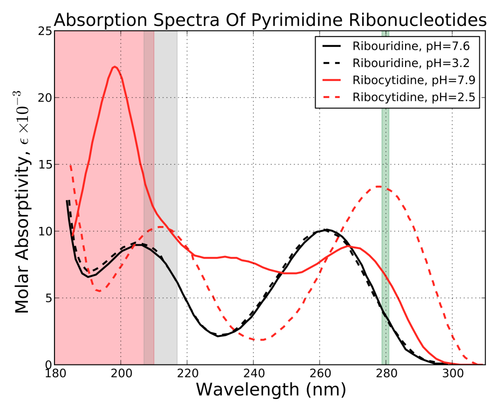

Fig 1: Absorption spectrum of pyrimidine ribonucleotides at different pHs, taken from [13]. Shaded in red is the spectral region shielded by the prebiotic atmosphere. Shaded in grey is the spectra region of the spectrum corresponding a flare feature [14]. Shaded in green is the spectral region corresponding to the Mg II hk lines [15].

References: [1] Cockell C. (2000) *Planetary and Space Science, 48.* [2] Chyba C. F. and Sagan, C. (1992) *Nature*, 355, 125. [3] Rosenberg R. et al (2008) *Physical Review Letters*, 101, 178301. [4] Sarker P. K. et al *Advances in Space Research*, 51, 2235. [5] Powner M. W. (2009) *Nature*, 459, 239. [6] Claire M. W. et al (2012) *The Astrophysical Journal,* 757, 95. [7] Ferris J. P. and Chen C. T. (1975) *Journal of the American Chemical Society*, 97, 11, 2962-2967. [8] Guzman M. I. and Martin S. T. (2008) *International Journal of Astrobiology*, 7, 271. [9] Powner M. W. et al (2007) *ChemBioChem*, 8, 1170. [10] Simonov A. (2007) *Advances in Space Research*, 40, 1634. [11] Matsunaga T. et al (1991) *Photochemistry and Photobiology*, 54, 3, 403-410. [12] Ritson D. and Sutherland J. D. (2012) *Nature Chemistry*, 4, 239. [13] Voet D. et al (1963) *Biopolymers*, 1, 193. [14] Cnossen I. et al (2007) *Journal of Geophysical Research (Planets)*, 112, 2008.