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Dragonfly: in situ investigation of Titan's astrobiological potential

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Titan is a prime target for astrobiology. Its abundant complex carbon-rich chemistry, interior ocean, and past presence of liquid water on the surface make it an ideal destination to study prebiotic chemical processes and document the habitability of an extraterrestrial environment [1, 2]. Pathways for the origin of life are poorly constrained, however there is general agreement that liquid water, a suite of essential elements (most significantly CHNOPS), some form of energetic disequilibrium, and a catalytic surface are all required. In addition to the level of organic synthesis that Titan supports today, opportunities for organics to have interacted with liquid water at the surface (e.g., sites of cryovolcanic activity or impact melt [3]) increase the potential for chemical processes to progress further, providing an unparalleled opportunity to search for chemical signatures of potential water-based or even hydrocarbon-based life. Ice crystals in refreezing cryolavas or melt may provide catalytic surfaces, and impacts may introduce silicate material. Moreover, during the first $\sim$ 3 Gyr of Titan's history the ice shell may have been relatively thin (<10 km) and exchange between the surface and subsurface would have been considerably easier. Deposits from that epoch of thinner ice could reveal the extent of aqueous/organic chemistry in the ocean, and possibly any potential biosignatures.

The diversity of Titan's surface materials and environments [4] drives the scientific need to be able to sample a variety of locations, thus mobility is key for in situ measurements. Titan's dense atmosphere provides the means to access different geologic settings over 10s – 100s of kilometers apart, via exploration by a vehicle with aerial mobility. Dragonfly is a rotorcraft lander mission currently being studied in Phase A under NASA's New Frontiers Program [5]. This revolutionary mission concept would explore diverse locations to characterize the habitability of Titan's environment, to investigate how far prebiotic chemistry has progressed [6]. Geophysical studies will also provide constraints on Titan's interior structure and ocean-surface exchange processes.
The initial landing site in an interdune flat provides access to materials with a water-ice component, as well as Titan's vast sediment sink of organic sand, which may represent a principal end product of Titan's organic chemistry [7,8]. Over its prime mission (>2 years), Dragonfly will travel to and explore a wide variety of additional surface sites, including locations where there is evidence of past liquid water, and therefore where there may be biologically relevant compounds [3]. Following characterization of each new site, the science team may command acquisition of a surface sample for detailed compositional analysis [9]. The mobility of the Dragonfly rotorcraft lander and its complementary instruments payload would allow us to address all of these aspects of Titan in a complete, integrated scientific investigation.

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