Introduction: The widely accepted minimum requirements for life on Earth include the presence of water and accessible sources of carbon. We assume that the same criteria must hold for putative life on past or present Mars. The evidence for CO₂ and H₂O at or near the Martian surface, carbon in Martian meteorites, aqueous alteration, and probable hydrothermal activity [1,2,3,4] suggest that conditions conducive to the origin and evolution of life on Mars may have existed for long periods of time and may still obtain at present. Surface exploration on Mars that enables the direct detection of water in minerals and of organic carbon (including not just organic and biogenic materials but their degradation products such as kerogen-like hydrocarbons and graphitized carbon) that might be products or residues of biologic activity, is crucial.

The search for evidence of life, past or present, will nevertheless be difficult. The lack of direct evidence for organic carbon and the low amounts of water found in the soils at the Viking sites demonstrated the difficulties [5]. Recent results of GRS experiment of Odyssey mission indicated the existence of abundant water ice beneath the Mars surface. Mineralogical evidence for the presence of carbonate, sulfates, or clay minerals, products of weathering and aqueous deposition, have not been identified unambiguously on Mars [6, 7]. Rocks such as shales and, more particularly, limestones, which we associate with moist and benign environments on Earth, are evidently not abundant. Presumably, then, neither were the photosynthetic organisms that might have produced them. In addition, the harsh present environment on Mars (e.g., dryness, low temperatures, large temperature cycles, high level of UV light on the surface, frequent dust storms, etc.) can both destroy carbon- and water-bearing materials and hide them. Therefore, directly detecting life-related materials on Mars was likened to seeking and examining proverbial needles in haystacks. We argue that “survey” type instruments, that can frequently and quickly check a relatively large amount of material at many locations during a mission, are essential.

A “survey” type sensor to be used on a rover should be very small, robust, and easy to deploy frequently or continuously. The measurements should be made quickly so as not to disturb the normal motion of the host rover and should produce only a small volume of data to be transferred; in most cases, a “yes” or “no” answer would suffice. Using commercial components, we have built a breadboard of a UV-stimulated fluorescent sensor. It is battery operated, has a size of 4” dia. × 4.5”, a mass of 510g, a field of view of 11 cm², and takes a measurement in 2 – 8 seconds. A system of this type (a size of 1” dia. × 1.5”, and 1 cm² field of view) could be mounted inside of a rover wheel and look outward through a hole in the “tire” so that a measurement could be made each time the hole in the wheel touched the ground; 18 m² of the martian surface could be surveyed during a 1-km traverse.

Fluorescent features of different materials: A basic premise of this survey method is that a simple...
fluorescent measurement might distinguish inorganic materials from biologic and other organic materials. To test this, we used the breadboard system, to take fluorescent images of 158 samples of different types and origins, including Martian meteorites, lunar rocks, terrestrial rocks and minerals, coral and shells, fungi and spores, fresh and dry plants, and animal bones. We used Adobe Photoshop to analyze the images. Several dark frames were taken at the extract same exposure setting as for the sample images. They were averaged, then subtracted from the sample images. A set of color correction factors for the breadboard system was established by analyzing the image of a standard white lamp (Kaiser Optical System Inc., as a 2750°C blackbody). The mean values of three color components (blue, green, red) from each sample image were extracted, corrected, and compared.

The analyzed samples can be divided into three groups according to the general strength of their fluorescence and the relative intensities of their color components in the fluorescence images. Samples in Group 1 show NO or extremely weak fluorescent emission under the excitation. This group includes Martian meteorite EETA79001, lunar rock 75075,154, fresh or slightly altered terrestrial igneous rocks (the FRB basalt, an Ortenburg basalt, grains of Hawaii volcanic ash, a Missouri granite, three deep-ocean drilling cores), terrestrial metamorphic rocks (a South Africa chert, a banded amphibolite, a marble), and some samples of sedimentary origin (sand from Hoare Lake in Antactica, an ammonite, a dolomite from Silverlake, a paleosol), and mineral grains of hematite, kyanite, orthoclase, and tourmaline. Samples in Groups 2 and 3 all show fluorescence under excitation, but differ from each other in emitting strength and spectral features (Figs. 1 and 2, same Y scale). Samples in Group 2 fluoresce more intensely than those in Group 3, particularly in the blue and green portions of the spectrum (Fig. 1). Group 2 includes fungi and spores, corals and sea-shells, dry plants, animal bones, travertine, and two amino acids. The samples in Group 3 have less intense fluorescence (Fig. 2). Their red and blue components have intensities similar to each other, but a much weaker green component. This group includes a basalt that is heavily hydrothermally altered, a slightly weathered granite, acid alteration products from a Hawaii basalt, several carbonate rocks of biogenic or non-biogenetic origins, some clay minerals (kaolinite, saponite), two sea-shells, and minerals containing fluorescing elements (Cr\(^{3+}\), Sm\(^{3+}\), Mn\(^{2+}\)). Three lunar rock samples (76135,29, 78235,20, and 77035,58) also belong to this group. They show very weak reddish fluorescence, and a color ratio similar to that of a Sm-YAG crystal, consistent with the fact that these lunar samples are enriched in rare-earth phosphates. Using the intensity ratios of the corrected and normalized color components from the fluorescent images, Figure 3 shows the life-related species (living organisms or residues, Group 2) can be distinguished from other non-biogenesis species. Fresh plant samples (leaves and flowers) were also analyzed, but did not exhibit fluorescence under the excitation. After these plant samples began to dry, their fluorescent intensity increased.

A filter can be added to the breadboard (an imager) to convert it into a “yes” or “no” sensor for detecting life-related species quickly. The filtering threshold could be adjusted, based on mission requirements, either high to reduce false alarms or low to detect every possibility.

**Conclusions:** A simple, small, robust fluorescence spectrometer can indicate the probable presence or absence of biogenically related organic materials in a rapid survey mode. Biogenic residues fluoresce more toward the blue and more intensely than the inorganic materials we analyzed. We have not yet determined the sensitivity of this method.

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**References:**