Science Capabilities of the Ocean Worlds Life Surveyor (OWLS) Microscope Subsystem

Christian Lindensmith[1], Jay Nadeau[3], Manuel Bedrossian[2], Taewoo Kim[2], Eugene Serabyn[1], J. Kent Wallace[1]

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
[2] GALCIT, California Institute of Technology, Pasadena, CA 91125
[3] Department of Physics, Portland State University, Portland, OR 9720

The optical microscope is one of the basic tools of microbiology, used for direct observations of microorganisms and their properties and behavior. The most basic form, brightfield microscopy, is commonly used to count cells, observe morphology and structure (both with and without stains), and observe motion. Some variations on the brightfield microscope, such as polarization and phase contrast, allow measurement of optical properties of cells or objects that can be used to infer physical properties such as index of refraction and chirality of molecules or birefringence of small crystals. Fluorescence microscopy, when combined with targeted stains, provides the ability to observe the distribution of molecular features in cells, such as lipid membranes, flagella and cilia made of proteins, and the nucleic acids that comprise the genetic material of the cell.

In most cases, optical microscopy is both necessary and sufficient for detection of extant microorganisms. In the presence of motility and clear cell structure, no further proof of life is needed. When cells are non-motile and featureless, morphology and morphological patterns in the context of the surrounding environment are highly informative; complex structures such as biofilms can also be identified. Contextual imaging at both larger spatial scales (1 cm-1 m) and smaller spatial scales (10 nm) can provide further biosignatures.

We have have constructed a compact, multi-mode optical microscope system that enables simultaneous observation using many of these techniques at micrometer scale resolution through a large enough volume to detect cells at concentrations below ~100/mL in times consistent with the concept of operations for the proposed Europa Lander mission. Here we present a summary of the laboratory and field demonstrated science capabilities of this instrument, including micrometer resolution imaging, stain-free phase imaging, index of refraction measurement, density estimation, fluorescent staining, and observations of passive and active motion.