Astrobiology and Mars in the NRC Decadal Survey. W. M. Calvin¹ and P. R. Christensen², ¹Geological Sci. & Eng. University of Nevada, Reno, NV (wcalvin@unr.edu), ²Arizona State University, Tempe, AZ (phil.christensen@asu.edu).

Introduction: In the 2003 Decadal Survey New Frontiers in the Solar System [1], Mars as a potential abode for life was identified as a primary unifying theme for martian studies. The Mars community, through the MEPAG process, keeps an active goals document including objectives and investigations to determine if habitable environments have ever existed on Mars, to understand how changes in climate have affected the surface habitability of Mars over the planet’s history, and to explore for evidence of past, or present Martian life [2]. The goals and objectives link into the broad architecture of existing and planned missions. Our first efforts at detection of organic materials since the Viking mission is planned for Mars Science Laboratory, to be launched in 2011. Astrobiology themes and goals will continue to inform future exploration in the decade from 2013 to 2022.

Why Mars? In the data gathering and community input activities of the Mars subpanel of the current Decadal Survey, it is clear that many consider Mars to have a special status in the solar system. Mars offers crucial information about the early evolution, internal structure, and origin of the terrestrial planets, including Earth. In particular, the timeframe for evolution of life on Earth is largely absent from the rock record, but this era is preserved on Mars. Thus, Mars provides a means to approach, and possibly answer, origin and evolution of life questions, with the added benefit of a focused, dedicated program of exploration with frequent launch opportunities and short spacecraft travel times.

The Fruition of Follow the Water: The past decade of intense exploration has revolutionized our knowledge and understanding of Mars and its potential past and present habitability. Among the major advances has been the identification of a growing inventory of diverse aqueous environments, the discovery of extensive water-ice reservoirs and active liquid water in recent times, the detection of methane in the atmosphere and the complexity of the atmospheric chemistry, a clear understanding of the importance of major climate oscillations that continue to the present time, and the mapping of ancient rocks of diverse compositions and origins that record the conditions and processes on a terrestrial planet early in our solar system’s history and its evolution through time.

Collectively these, and many other discoveries, have set the stage for the next steps in Mars exploration. Among the key questions are: what has been the nature and role of water on Mars? Its occurrence is well established, but what are the detailed properties and processes, such as its chemistry, timing, distribution, and duration, that led to the diverse environments preserved in the different mineralogic suites that are observed? What are the causes and effects of climate change and atmospheric evolution on Mars, and how do these relate to climate changes on Earth elsewhere? And perhaps most significantly, did life ever arise on Mars, and if so, is it there today? If not, what conditions differed from those on Earth that prevented its emergence? Can the early pre-biotic chemistry be determined?

MGS to MSL: The study of Mars over the past dozen years has been built around two cycles of exploration, each initiated by orbital observations and followed by in situ landed science. The first cycle began with the Mars Global Surveyor and Odyssey orbiters, followed by the Pathfinder, Mars Exploration Rovers, and Phoenix surface missions that field tested the hypotheses framed from orbit. The second cycle began with the exquisitely detailed information coming from the Mars Reconnaissance Orbiter, which will be followed by the Mars Science Laboratory, the MAVEN aeronomy orbiter, and ESA’s ExoMars rover and surface package.

2013 to 2022: Among the highest priorities for new missions in this decadal survey is an orbiter to study the origin and evolution of trace gases and atmospheric chemistry and a surface rover that will take the first steps toward sample return by caching a selection of samples. The science goals for the Trace Gas Orbiter (TGO) are to provide global, diurnal and seasonal survey of key trace gases, including carbon, nitrogen and sulfur-bearing compounds and their isotopologues with implications for interior bio/geochemical processes and photochemical products. A major advance toward addressing the questions of early conditions and life will come from returning samples of Mars to Earth, although the timing for sample return is beyond the horizon of this decade. Goals for an astrobiology/exploration/caching rover are to 1) land or rove to a terrain that has bedrock exposures that will allow reconstruction of past environmental conditions and provide information about habitability and life 2) acquire, package, and preserve a rock core sample cache for return to Earth and 3) characterize the geological, mineralogical, and compositional contexts for rock samples collected and cached.