Statement of

Dr. Thomas Zurbuchen
Associate Administrator
Science Mission Directorate
National Aeronautics and Space Administration

before the

Committee on Science, Space and Technology
U.S. House of Representatives

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the topic of astrobiology. As you all know, this is an exciting time for space exploration and discovery, and especially the search for life elsewhere, and I would like to begin by expressing our gratitude for the Committee's long-term support of our efforts in this area.

In particular, we are pleased by the Committee's inclusion of a provision in the recently passed NASA Transition Authorization Act of 2017 that expressly makes astrobiology and the search for life part of NASA's core statutory mission. We are not only committed to but also enthusiastic about accomplishing the objectives that Congress and the President have laid out for us. Furthermore, NASA is initiating work with the National Academies to develop science strategies for astrobiology and the study of exoplanets as requested by the 2017 Authorization Act. Once complete, these strategies will be used in planning and funding research and other activities as well as to provide a foundation for future initiatives related to astrobiology and exoplanet research.

I have been working in NASA's Science Mission Directorate (SMD) for about seven months now and have come to appreciate the shear breadth and depth of our mission portfolio. And while most often, we think about our missions in terms of the science area in which it is managed, such as Astrophysics or Planetary Science, I find it useful to think about these missions in terms of how they contribute to three themes that are central to everything we do.

The first of these themes is that we seek to expand knowledge – by investing in fundamental research to increase what we know and enlarge the space in which we live. Secondly, SMD is working with the greater scientific community on a focused science objective to search for life elsewhere, our second theme, which we will highlight today. The third theme is safeguarding and improving life on Earth, which refers to the research and missions from many disciplines that directly affects people on the ground, including Earth science, space weather and planetary defense. We are excited and inspired when SMD's fundamental research has direct and positive impacts in our lives!

As part of our astrobiology effort, NASA supports research that leads to a better understanding of how life emerged and evolved on Earth, what conditions make any environment in our universe capable of supporting life, and what is the potential distribution of habitable worlds and life itself beyond Earth. Searching for life elsewhere is a collaborative and interdisciplinary theme by necessity. To fully engage in this pursuit, we need a convergence of the areas of biology, heliophysics, Earth science, astronomy, planetary science, and the astrophysical search for Earth-like planets that might show signs of life. Together, researchers in these fields are exploring one of the greatest questions of our time.

For example, just two weeks ago, NASA's Cassini mission confirmed the presence of hydrogen from plumes on Saturn's moon Enceladus while our Hubble Space Telescope team announced the second observation of possible plumes near the equator of Jupiter's moon Europa. Both discoveries display the potential for life-enabling energy sources in oceans hidden from view under an icy crest, a confirmation of which would be significant to all of NASA. That's because scientists believe the plumes are spewing from cracks in these moons' icy shells with material indicative of hydrothermal activity on their ocean floor; and we know that within many hydrothermal vents in our deep oceans on Earth, we find life. Scientists are currently debating if life may have originated at locations like these.

And while we haven't found definitive signs of life elsewhere just yet, our search is making remarkable progress and astrobiology is a focus of a growing number of NASA missions.

One such mission is NASA's *Curiosity* rover, which has found evidence that ancient Mars did have the right chemistry to have supported microbial life as well as evidence that the raw ingredients for life to get started existed on the red planet at one time. Since landing in 2012, the rover has also found evidence of an ancient streambed and just last year, found chemicals in rocks that suggest Mars once had more oxygen in its atmosphere than it does now, indicative of a disequilibrium that also points to an environment supportive of past life.

Mars 2020, our next rover currently in development, will continue to advance this search by investigating a region of Mars where the ancient environment may have been favorable for microbial life. On the rover's mast, two science instruments will provide high-resolution imaging and three types of spectroscopy for characterizing rocks and soil from a distance, also helping to determine which rock targets to explore up close. Two science instruments mounted on the Mars 2020 rover's robotic arm will be used to search for signs of past life and determine where to collect samples by analyzing the chemical, mineral, physical and organic characteristics of Martian rocks. Throughout its investigation, it will collect samples of soil and rock, and cache them on the surface for potential return to Earth by a future mission. Given the sophisticated instrumentation available on Earth, returned samples could provide the biggest leap forward in understanding the biological potential of Mars. NASA is exploring a range of possible ways to potentially return these cached samples to Earth, including a future NASA Science or NASA-sponsored mission, or via a commercial or international partnership. We are exploring opportunities to partner with industry to leverage their future missions to advance decadal survey science objectives.

Beyond Mars, we focus on the ocean worlds of our outer solar system. A particularly interesting destination is Jupiter's moon Europa - which appears to meet the minimum requirements for life. Thus, NASA is currently developing a Europa *Clipper* mission, which will conduct a detailed reconnaissance of Europa and investigate whether the icy moon could harbor conditions suitable for life. The mission’s nine science instruments include cameras and spectrometers to produce high-resolution images of Europa's surface and determine its composition. An ice penetrating radar would determine the thickness of the moon's icy shell and search for subsurface lakes similar to those beneath Antarctica's ice sheet.

The mission would also carry a magnetometer to measure the strength and direction of the moon's magnetic field, which would allow scientists to determine the depth and salinity of its ocean. Finally, a thermal instrument would survey Europa's frozen surface in search of recent eruptions of warmer water at or near the surface, while additional instruments would search for evidence of water and tiny particles in the moon's thin atmosphere.

The promise of Europa Clipper is increasing: As previously mentioned, NASA's Hubble Space Telescope has recently observed collimated water vapor near Europa’s equator multiple times, providing evidence of water plumes. If the plumes are linked to a subsurface ocean, studying their composition would help scientists investigate the chemical makeup of Europa's potentially habitable environment while minimizing the need to drill through layers of ice.

Beyond our solar system, a transformation of understanding is taking place regarding planets around other stars, or exoplanets, by means of NASA missions. To me, this tantalizing set of science discoveries is woven into my personal story.

I grew up in a small farm town in the Swiss mountains, one of the most beautiful places on Earth. By day I would explore the snowcapped mountains and crystal blue lakes, and by night the brilliant stars would transfix me with their beauty and seemingly endless number, sitting on the roof of our house with a star-map. How many of them were there, I wondered? I read books in the library and began learning more and more about the sheer magnitude of the universe, the peculiar objects that were in there, like exploding stars, black holes, neutron stars and speculation about worlds around other stars, possibly worlds just like ours.

I was in graduate school when the first planet orbiting a “normal” star other than our own was announced by a team of Swiss astronomers. This planet, 51 Pegasi b, was large like Jupiter (half the mass), but orbited closer to its star than Mercury does to our Sun, speeding through its entire orbit in only four days. To say that this discovery was a surprise is a huge understatement – no one thought that giant planets could exist in such close proximity to a star. This discovery was met with skepticism – but within a few months it was confirmed by a U.S. team using the Lick Observatory in California and a new field of astronomy was born. Now, with NASA missions like the Kepler and Spitzer Space Telescopes, we have discovered more than 3,400 exoplanets, with billions more just waiting to be revealed in our galaxy alone.

This February, NASA's Spitzer Space Telescope team announced the discovery of seven Earth-sized planets, the most ever, found around a single star, called TRAPPIST-1. Three of these planets are firmly located in the habitable zone, the area around the parent star where a rocky planet is most likely to have liquid water. This system of seven rocky worlds – all of them with the potential for water, a key to life as we know it – is an exciting discovery in the search for life on other worlds. The TRAPPIST-1 system is just 39 light years away and its discovery tells us that there is plenty of planet making material in our little corner of the solar system, indicating that finding Earth-like planets may actually be closer to us than we originally thought. Future study of this planetary system could reveal conditions suitable for life. Since the initial observations, the follow-on findings for TRAPPIST-1 (and exoplanets in general) are occurring almost weekly, but the best is yet to come.

NASA's Spitzer, Hubble, and Kepler Space Telescopes will continue to help astronomers plan for such follow-up studies using NASA's upcoming James Webb Space Telescope, launching in 2018. With much greater sensitivity, Webb will be able to detect the chemical fingerprints of water, methane, oxygen, ozone, and other components of a planet's atmosphere. Webb also will analyze planets' temperatures and surface pressures – key factors in assessing their habitability.

The Transiting Exoplanet Survey Satellite (TESS) mission will also launch next year, to survey the entire sky for nearby exoplanets, and the Wide Field Infrared Survey Telescope (WFIRST), launching in the mid-2020s, will directly image exoplanets and study their atmospheric chemistry for the first time using reflected light from their stars. NASA is studying mission concepts even beyond these near-term missions for the 2030s that would further explore and characterize the bounty of possible habitable Earth-like planets. These mission concepts include the Habitable Exoplanet Imaging Mission and the Large Ultraviolet/Visible/Infrared Surveyor, which would operate from the ultra-violet to the near-infrared like Hubble and WFIRST, and the Origins Space Telescope, which would operate from the mid-infrared to the far infrared like the James Webb telescope.

With all of this activity related to the search for life, in so many different areas, we are on the verge of one of the most profound discoveries, ever. And as we know from experience, NASA's scientific discoveries of today continually drive impactful research for tomorrow that goes far beyond the initial observations.

For astrobiology, the key thing to remember is that answering the fundamental question of "is there life out there?" will require scientific breakthroughs from many different science fields, including ones that are not currently engaged in this exciting endeavor. This, however, demonstrates the nature of great research: it's not just about answering questions that have been asked in the past, it is about finding entirely new questions that will have impact for a long time to come.

Again, thank you for the opportunity to testify today. I look forward to responding to any questions you may have.