In June, 2004, after seven years and a billion miles, the space probe was approaching Saturn. It was named after Renaissance astronomer Jean-Dominique Cassini. Mission control personnel, scientists and their families held their collective breaths as Cassini commenced a 96 minute burn of its rockets that would use all but 20 percent of its fuel. If the burn was too short, Cassini would fly by Saturn, never to return. Its speed would be too great to allow it to be captured by Saturn's gravitational field. If it burned too long, there would not be enough remaining fuel to accomplish the exploratory mission.

At 9:12 in the evening, local time, a radio transmission arrived from Cassini, 900 million miles away. The burn had been successful. Cassini was in orbit around Saturn.[i]

Since Galileo first observed Saturn's rings in 1610, humans have been captivated by this beautiful and mysterious planet. I've been captivated by the Cassini story this week. I did not plan that today's message would be two days after the culmination of this 20 year mission to Saturn. That was serendipity.

The video watched a few minutes ago brings tears to my eyes. Tears for the beauty of Saturn and its moons.[ii] Tears for the 100's of dedicated scientists and engineers who have devoted entire careers to this mission. Tears for the beauty and elegance of the science that made this mission such a success. Tears for the end of the mission.

The Saturn mission was conceived in 1982. It was to be a joint project between the European Space Agency and NASA, with the Europeans building the lander, which was to investigate the Saturn's largest moon, Titan. It was named Huygens, after the Dutch astronomer Christiaan Huygens, who discovered Titan in 1655. The United States was to be responsible for building Cassini, the orbital craft that would glean as much information as possible about every other aspect of Saturn. Congress, ever ready to cut NASA's budget, almost didn't approve Cassini. Only the fact that the Europeans had already invested hundreds of millions of dollars in building the Huygens lander likely prodded Congress into approving of our part of the mission in 1989. I wonder if it would have been approved in today's toxic political environment.

There are so many disciplines in science, each with its own questions. In our children's story we heard of another interplanetary mission, to Pluto. In Dave's reflection we heard how science is a particular way of thinking about things, about truth, about beauty, that is not just done by professional scientists. Rather than try to paint a broad brush stroke, with a little bit of many things, I am going to speak of the Saturn mission specifically as a microcosm of all of scientific inquiry and the search for truth and beauty. The scientists that took part in this mission came from a broad spectrum of disciplines.

Imagine, if you will, that you are a scientist whose specialty has something to do with Saturn. The rings. Titan. Encelidus. Storms. Extra-terrestrial life. Many, many more that I've not mentioned. Now, you are collectively tasked with designing a space craft that can address as many of your questions as possible. A space craft about the size of a school bus. A vehicle with

strict weight and cost limitations. Now imagine that you are on that team of scientists seven years later when data begins to pour in. Each transmission from Cassini raises new questions. The mission is dynamic, changing as it progresses, while not giving up on the original goals. Imagine the arguments and ultimately, the cooperation, about what gets priority. This mission was a microcosm of how science gets done, both messy and beautiful. Richard French, a professor at Wellesley College and team leader for the radio science instrument on Cassini, had this to say: "Learning how to be cooperative with other scientists when you have a competition for resources has been really eye-opening. For me personally, the collaborations have been the most fun part of the mission, where you acknowledge that working together brings out the best science."

Once the scientists concurred on their priorities, there was the small problem of how to get Cassini into the right place to make the observation. This was done through judicious use of the thrusters, each burn using up precious fuel. The thrusters were used to push Cassini into a different trajectory. The rest was up to gravity.

The so-called "sling shot" is a fundamental tool in space exploration using spacecraft. The spacecraft is put on a trajectory that has it fly by another planet or moon or the sun and use the acceleration of the gravity field of that body to alter course and accelerate the spacecraft. Remember those story problems from math in high school. Ballistics. Parabolic arcs. Gravitational acceleration on earth. 32 feet per second per second. For some of you I may be bringing up nightmares. Now imagine the mathematics involved in that same basic type of calculation, but adding in different gravitational fields with different accelerations. Adding in the speed of the different bodies, Venus, Earth, the different moons of Saturn. The complexity of these calculations is mind-boggling. Yet beautiful. For a pure mathematician, the elegance, the beauty of the calculations is enough. For the persons calculating the trajectory of Cassini, there was that, but there was also the beauty of seeing their calculations validated in getting the spacecraft from Earth to Saturn and to all the various points around Saturn that scientists wanted to visit.

The rings of Saturn are what first captivated humans. With the observations made by Cassini, we now know that this ring system is only about 30 feet thick. Thirty feet, yet clearly visible to us through inexpensive telescopes. The rings rotate at different speeds, with the inner rings rotating faster. There are waves and ripples in the rings, as we saw in the video, created by the gravitational fields of the moons and Saturn itself. They form a complex system, and scientists will be years analyzing the data they received.

Of the many, many surprises unveiled by Cassini and Huygens, perhaps the most exciting, especially to the lay person, was the moon Encelidus. The Voyager mission had provided some clues, from pictures, that Encelidus might not be quite the dead moon that everyone expected it to be. There were other clues, from Saturn's rings, that something unusual was going on. It was slightly possible, thought some scientists, that Encelidus was responsible.

The results of the first fly-by proved them right. The moon was spouting an enormous plume of material out into space. The mission was altered to include closer investigation of Encelidus. As we heard in the video, Encelidus is covered with a vast salty ocean of water covered by ice. The water is kept from freezing by energy imparted through the enormous gravity of Saturn, causing huge tides beneath the ice. The plume is made up of ice crystals, which were found to contain salts and minerals, ingredients necessary for life as we know it. In fact, only two life ingredients may be missing, phosphorous and sulfur. May be, because Cassini wasn't equipped to test for them. Testing for these elements and for life itself will be left to a future mission.

The search for truth and beauty. Beauty and truth. Creation. The mystery of life. The scientists involved in the Cassini-Huygens mission were in search of all of these things. How are they happening in the Saturn system? What can they tell us about other parts of our solar system. What can they tell us about Earth? What can they tell us about the capacity for life?

Einstein once wrote, "The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science."[iii] I would add that it is the fundamental emotion that stands at the heart of why we humans are religious. In our Unitarian Universalist practice, we are led by the beautifully mysterious in a free and responsible search for truth and meaning.

May it be so.

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[i] Eval Botkin-Kowacki and Charlie Wood. Ringing Success. The Christian Science Monitor Weekly. Sept. 11, 2017. 24-30.

[ii] Dennis Overbye, Jonathon Corum and Jason Drakeford. Cassini Burns Into Saturn. New York Times. Video. https://www.nytimes.com/2017/09/08/science/cassini-saturn-nasa.html. Accessed 9/17/2017.

[iii] Albert Einstein. Readings from the Common Bowl. Touchstones monthly Journal of UU. Kirk Loadman-Copeland, ed. 3.