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Looking for Life in All the Wrong Places

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"No one would have believed in the last years of the nineteenth century that this world was being watched keenly and closely by intelligences greater than man's and yet as mortal as his own... With infinite complacency men went to and fro over this globe about their little affairs, serene in their assurance of their empire over matter... It is curious to recall some of the mental habits of those departed days. At most terrestrial men fancied there might be other men upon Mars, perhaps inferior to themselves and ready to welcome a missionary enterprise. Yet across the gulf of space, minds that are to our minds as ours are to those of the beasts that perish, intellects vast and cool and unsympathetic, regarded this earth with envious eyes, and slowly and surely drew their plans against us. And early in the twentieth century came the great disillusionment."

– *The War of the Worlds*, H. G. Wells

In H.G. Wells' 1898 book, *The War of the Worlds*, highly evolved beings from Mars attack Earth in order to capture a living, water-filled planet, only to be defeated by Earth's tiniest creatures, the bacteria. *Illustration from a 1906 French edition of the book.*

Water is critical to the existence of life. All known terrestrial life is built on an aqueous chemistry. That isn't a theoretical statement, nor do we have any reason to believe that the statement is an absolute truth. It's just an observed fact.

Nonetheless, water is the *sine qua non* of life on Earth. Where water is absent, life doesn't exist on this planet. But the presence of water isn't sufficient either. There are broad regions of the Earth where life hasn't been able to make a go of it, and the icecaps of Greenland are one of those places.

Chris McKay, an astrobiologist at NASA's Ames Research Center, Mountain View, CA, points out something that would shock any ecologist: "It's often said that life covers everywhere on this planet. It's not true. There are large places on this planet where no life forms have figured out how to make a go of it. The ice environment is one of them."

Is the a priori demand for liquid water a good model for life elsewhere? At the moment we don't know. "Follow the water" is NASA's mantra in its exploration of the solar system in their search for a second genesis of life. It’s the most conservative approach we can take, simply because we know it works.

Where liquid water is absent on this planet, life “checks out,” and McKay has been exploring three regions of the planet to understand the process: in the dry valleys of Antarctica, in the Atacama desert of Chile, and the tops of the high tropical mountains in the African rift.

None of these places are perfect analogs of Mars, but they are in many ways similar. Although current evidence suggests that the surface of Mars is inimical to terrestrial life, there remain plausible scenarios for extant microbial life on Mars, but only of very modest plausibility.

The surface of Mars today is far more inhospitable to life than any of these areas on Earth. It's cold, dry, chemically oxidizing and is exposed to an intense flux of solar ultraviolet radiation. Temperature is of interest, not only because of its controlling influence on metabolic rates but also because of its influence on the stability of liquid water.

The core thesis of H.G. Wells’ *War of the Worlds* is the same as NASA’s: the search for water, albeit in reverse. Wells’ Martians didn’t need our women, as the 1950’s B-movies suggested, but they desperately wanted our water.

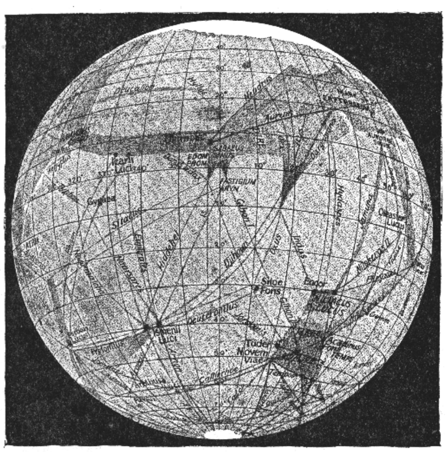


FIG. 2.

The highly architected canals of Mars, designed to transport water from the poles to the warmer equatorial regions, as perceived by Lowell.

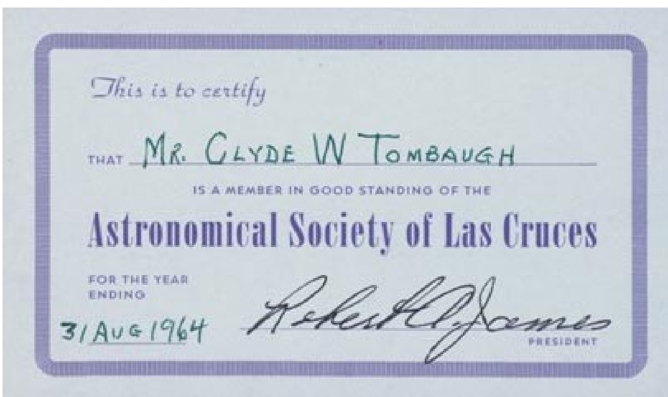
Of interest, Wells’ fictional story and the founding of the ASLC are intimately related. The story is well known. In 1877, the Italian astronomer Giovanni Schiaparelli, the director of the Milan Observatory, believed that he had observed long straight features he called *canali* in Italian, meaning “channels,” but which was mistranslated into English as “canals.”

This mistranslation set off a firestorm in the English-speaking world. The notion of canals immediately implied the engineering characteristic of an advanced civilization trying to stave off its extinction on an increasingly arid planet.

This idea was the basis of Wells’ story, but it was also the thought that greatly excited the wealthy Percival Lowell. In 1894, after retiring from his travels in Japan and Korea, Lowell chose Flagstaff, Arizona Territory, as the home of the new observatory he built in order to investigate the idea of an advanced civilization on Mars. At an altitude of over 7000 feet, with few cloudy nights, and far from city lights, Flagstaff was an excellent site for astronomical observations. The observatory he founded on Mars Hill marked the first time an observatory had been deliberately located in a remote, elevated place for optimal seeing.

For the next fifteen years Lowell studied Mars, making intricate drawings of the surface markings as he perceived them. Lowell published his views in three books: *Mars* (1895), *Mars and Its Canals* (1906), and *Mars As the Abode of Life* (1908). With these books, Lowell more than anyone else popularized the long-held belief that the lines on the surface showed that Mars sustained intelligent life forms.

Lowell passed away on November 1916 and is buried in a mausoleum the grounds of the observatory. Although Clyde Tombaugh never met Lowell, their careers were intimately intertwined, as are ours now. Clyde came to work at the Lowell Observatory in January, 1929, as a twenty-three year-old Kansas farm boy, self-taught in astronomy. Based on his demonstrated skill and interest, Tombaugh was hired as an assistant to aid in the search for new planets. He discovered Pluto a mere 13 months later, in February, 1930.



Clyde Tombaugh's ASLC membership card from 1963. Clearly, the organization was a much more formal affair then, going so far as to issue membership cards.

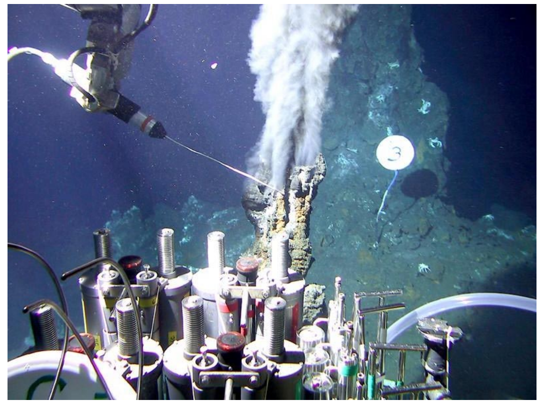
Following the war, Tombaugh came to Las Cruces in 1946 to work at the newly formed White Sands Proving Ground, and very shortly thereafter, helped found the Astronomical Society of Las Cruces in October, 1951.

The subject of Mars was never very far from Clyde's thoughts. I first met Clyde in 1964, as a sophomore, when I began taking a series of astronomy and earth science classes from him. He *was* the astronomy department at the time, although the university had no formal recognition of it as such. He began teaching astronomy classes within the Department of Earth Sciences in 1961.

The vision of Mars that Tombaugh advocated in the 1960's has proven to be exquisitely accurate: a cold, arid desert, blanketed with a carbon dioxide atmosphere 1/100th that of Earth's pressure, with no possibility of liquid water on the surface, but with the polar caps composed of both water and carbon dioxide ices. This description has been borne out by the first Mariner mission to Mars in 1967, the Viking Landers in 1976, Pathfinder in 1997, the MER rovers in 2004 and now by the Phoenix Lander this year, which is currently clawing its way through a thin topsoil, reaching a rock-hard layer of water ice in Mars' arctic regions.

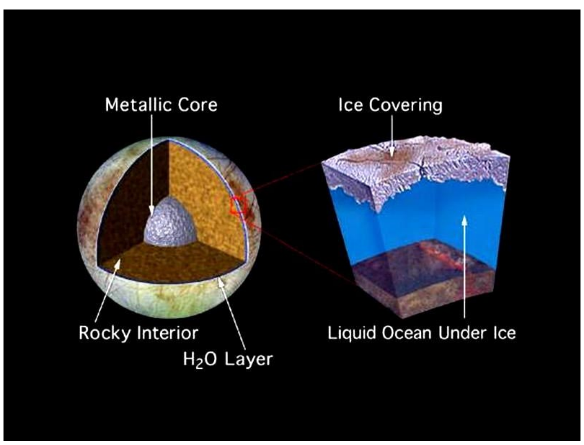
Clyde passed away in 1997, eighty-one years after Lowell. In the hundred plus years since Lowell and Wells spun their stories, Mars has slipped in probability of being the second most likely place to harbor life in this solar system to virtually no probability at all, but none of this would have surprised Clyde. What truly would have surprised him is the thing that has surprised us all: where we think the water is now that could foster a second, independent genesis of life.

In 1977, we made a discovery that astonished every biologist. We found a form of life on this planet that wasn't in any way connected to the light of the Sun. This life could have evolved anywhere. Chemosynthetic ecosystems surrounding deep submarine hydrothermal vents were discovered along the Galapagos Rift by a group of marine geologists studying ocean temperatures. In 1979, biologists returned to the rift and used the *Alvin*, a deep-sea submersible from Woods Hole Oceanographic Institute, to see the hydrothermal vent communities with their own eyes.



Deep sea hydrothermal vents occur on the ocean floor near tectonic plate boundaries. The heat and chemical complexity that they pour out may have been the places where life first formed on Earth.

Here was a form of life on this planet that we never knew existed. It was still DNA-based, identical to all other life on Earth, but metabolically distinct and very ancient.



If the "thin crust" of ice model of Europa is correct, then an ocean twice the volume of Earth's ocean exists below an ice covering. Due to the tidal forcings caused by the constant tug of Jupiter and Europa's sister moons, hydrothermal vents almost certainly exist on Europa as well. If so, the probability of an independent, second genesis of life in this solar system is very high.

Iron sulphide is pumped out of the hydrothermal vent chimneys at very high temperatures and pressures, forming pyruvic acid, a key constituent that life commonly uses to extract energy from food. Temperatures in the vents can reach 500 C. More importantly, the vents spew out a cocktail of basic chemicals at scorching temperatures under very high pressures.

A good many scientists now believe that the most important ingredients in the formation of all life on Earth are found around these vents. Gunter Wachtershauser, a prominent origin-of-life researcher, has commented that the new research was another piece of the jigsaw. "It means you don't need an [entire] ocean to create life. All you need is a little water vapor and a lot of volcanic activity."

Contemporaneous with these discoveries, we began sending spacecraft to the giant planets and we found oceans of water, potentially much larger than those of the Earth, that we never knew existed. Beginning first with the Voyager spacecraft, and then later with the Galileo and Cassini missions, we're nearly positive that we've discovered subsurface oceans on Europa, a Galilean moon of Jupiter, and in tiny Enceladus, a moon of Saturn.

Exploring these moons will be a monumental engineering task. Jupiter's radiation environment makes the surface of Europa uninhabitable for any form of life, especially human life. Nor is it an easy regime for machines. But that lethality only exists on the surface of the ice. It's believed that just a very few feet down into the ice, the radiation environment becomes quite benign, and there are miles of ice to go before we would get to the subsurface ocean.

Mars and Venus lost their oceans approximately 3.5 billion years ago, but Earth still retains a significant fraction of its original ocean, and Europa appears to be awash in water. We have no missions currently planned to explore Europa, but there is a great deal of eagerness in the scientific community to do so. Two years ago, Robert Pappalardo, of the University of Colorado, said, "We've spent quite a bit of time and effort trying to understand if Mars was once a habitable environment. Europa today, probably, is a habitable environment. We need to confirm this, but Europa, potentially, has all the ingredients for life – and not just four billion years ago – but today."

Next Month: The Perspective that Age Brings