SETI -

Search for Extra-terrestrial Intelligence

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PERCIVAL LOWELL AT THE 24 INCH REFRACTOR, FLAGSTAFF, ARIZONA OBSERVING MARS DURING FAVORABLE OPPOSITION (PERIHELIC OPPOSITION) OF 1894

BELOW IS A GLOBE CONSTRUCTED FROM HIS DRAWINGS
Viking composite of Mars

mid 1970’s
The Miller-Urey Experiment


Left: Stanley L. Miller (1930-2007) with a reproduction of the experimental setup he first used in the 1950’s to study pathways to the origin of life.
Life in the Solar System?

Pole-to-Equator Temperature Difference on Other Planets

- ~0 K
- ~4 K
- A few 10 K
- A few (more) 10 K

Thicker Atmosphere
**Needed for Habitability?**

- Solid surface
- Atmosphere
- Liquid on surface: Need not be water

**PHI – Planetary Habitability Index:**
Schulze-Makuch et al., 2011
Habitability Index

Earth = 0.96
Titan = 0.64
Mars = 0.59
Gliese 581d = 0.43

Credit: Popular Science
Europa

- Metallic Core
- Rocky Interior
- H₂O Layer

- Cold Brittle Surface Ice
- Warm Convecting Ice
- Ice Covering
- Liquid Ocean Under Ice
Enceladus
Titan
Landed January 14, 2005 at 10.2S, 192.4W

Discovered small “rocks”, possibly made of water ice, at the landing site.

Fluvial activity (methane?)

Images taken during descent showed no open areas of liquid, but indicated liquid had once flowed.
Possible Shoreline
Life Around Other Stars
Massive, Class A stars are about 20 times brighter than the Sun, with wide habitable zones. But the stars are rare and short-lived, leaving only a billion years for orbiting planets to form and for life to develop.

Large, Class F stars are also rare, making up only 2 percent of all stars. But with a lifetime of several billion years, the stars could provide ample time for life to form, making them tempting targets for planet hunters.

The Sun is a class G star. Earth orbits near the inner edge of the habitable zone, and Venus and Mars come close, depending on whether researchers use optimistic or conservative estimates for the Sun's habitable zone.

Estimated habitable zone
- Optimistic estimates
- Conservative estimates

Orbit of Mars
Earth
Venus
Mercury
Sun (G)

Orbit of Earth
Birth of the Sun
2 billion years ago

An aging Sun
Stars brighten with age, and the early Sun was about 30 percent less luminous than it is now.

As the Sun ages, its habitable zone will continue to shift outward. In several billion years, Earth's water will evaporate away, unless future inhabitants relocate or use technology to prevent it.

A sliding scale
The chart at right shows the estimated habitable zone for different sizes of star, and highlights known exoplanets of HD 85512, in the constellation Vela, and Gliese 581, in Libra.

An orbit in or near the habitable zone does not ensure surface water. Earth's moon, atmosphere, mass, volcanic and tectonic activity all contributed to habitability.

Astronomers stress that distant exoplanets will require more than a good orbit to support surface water and the possibility of life.

Locked to a star
Planets to the left of this line tend to orbit with the same side always facing the star, a process called tidal locking. A tidally locked planet might have one side too hot for surface life, and one side too cold.

Earthlike planets
Rocky planets within this zone are of special interest to planet hunters. Gas giants (like Jupiter) and ice giants (like Neptune) will form farther out from the star, but they can then migrate inward to become so-called "hot Jupiters" in very close orbits.

1 Astronomical Unit (A.U.)
Distance from Earth to Sun
The Drake Equation

How many civilizations are out there?
ARECIBO OBSERVATORY
ARECIBO, PUERTO RICO

NATIONAL ASTRONOMY
AND IONOSPHERE CENTER
OPERATED BY CORNELL UNIVERSITY
UNDER COOPERATIVE AGREEMENT
WITH THE
NATIONAL SCIENCE FOUNDATION
Arecibo Message

Broadcast on November 16th 1974 from the Arecibo radio telescope.

Aimed toward globular star cluster M13.

M13 is 25,000 light years away.
182 ▲ IS ANYONE OUT THERE?
(Frank Drake)

1679 = 73 x 23 (both primes)
10 bits per sec = 3 min

C₅H₁₀

PO₄

O₂, N₂, H₂

H₂O

OCS₂H₆

ONC₅H₄

OC₅H₄

ONC₅H₄

ONC₅C₅H₄

OC₅H₅

PO₄

105°

25° 44'

105°

25° 44'

A

Abanine

N₂C₅H₄ = Adamine

ONN₂C₅H₆ = Thymine

ON₂C₅H₆ = Guanine

ON₃C₅H₆ = Thymine

ON₂C₅H₆ = Cytosine

FIGURE 8.10. Diagram of the Arecibo radio message t
ted toward the Great Cluster in the constellation ζ (1974).

OC₅H₅ = Deoxyribose
2 base pair
whole human genome.
CONTACT

A message from deep space
Who will be the first to go?
A journey to the heart of the universe.

JODIE FOSTER
MATTHEW McCONAUGHEY

From the Academy Award-Winning Director of "Forest Gump" and the Pulitzer Prize-Winning Author of "Contact."
Launch of the Kepler Spacecraft

SUCCESSFUL LAUNCH: 2009 March 6 at 10:49 pm EST.

Video resources:
- 21 Mb AVI (best for PCs)
- 2.5 Mb MPEG4 (best for fast download)
- 17 Mb Quicktime (best for Mac)

Photo below by Ben Cooper
http://www.launchphotography.com
Imagined View from Planet Kepler-10b (Artist's Depiction)
Credit: NASA/Kepler Mission/Dana Berry
**Planet habitability index**

Selected bodies, 2011, 1=maximum

- **Solar-system planet**
- **Solar-system moon**
- **Exoplanet**

<table>
<thead>
<tr>
<th>Planet</th>
<th>Solar-system planet</th>
<th>Solar-system moon</th>
<th>Exoplanet</th>
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<tr>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>55 Cancri c</td>
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Source: Astrobiology
In Disasters, Panic Is Rare; Altruism Dominates

ScienceDaily (Aug. 8, 2002) — WASHINGTON, DC -- Group panic and irrational behavior did not occur at the World Trade Center on September 11, 2001. Instead the event created a sense of "we-ness" among those threatened, says Rutgers University sociology professor Lee Clarke. In his article, "Panic: Myth or Reality?", in the fall 2002 edition of Contexts magazine, he explains that 50 years of evidence on disasters and extreme situations shows that panic is rare, even when people feel "excessive fear."

Rarity of Panic

Because this combination of conditions is so uncommon in disasters, panic is also quite rare. (6, 7) When panic does occur, it usually involves few persons, is short-lived, and is not contagious. (21) In studies of more than 500 events, the University of Delaware's Disaster Research Center found that panic was of very little practical or operational importance. (21, 22) A number of systematic studies of human behavior in disasters have failed to support news accounts of widespread panic. (5, 8, 23–26)