Viking Lander Biology Missions and Experiments

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Is there life on Mars?
Are we alone out here?

- Humans are instinctively curious about who else is “out there.”
- Biology experiments were developed and sent to Mars to try to answer this key question.

http://img.dailymail.co.uk/i/pix/2008/01_04/LifeOnMarsBARC_800x496.jpg

Oparin-Haldane Hypothesis

Scientists Alexander Oparin and John Haldane formed a Hypothesis on the Origin of Life on Earth.

•The basic premise was that the Earth's original atmosphere went through synthesis, powered by various energy sources and became a "prebiotic soup" from which all life forms evolved.

Fig 3.1.3c : Prebiotic atmosphere consisting of H_2O, CH_4, NH_3, H_2 and HCN

•These first organic compounds formed in the atmosphere. They were then transported via rain into the rivers, lakes and oceans of the world where they proceeded to accumulate.

Due to the high concentration of molecules, collisions occurred which powered further spontaneous reactions causing molecular or chemical evolution. (Transforming the simple molecules into complex ones.)

http://upload.vipulg.com/Biology/600/Part%20II/Chapter%203_files/Chapter%203-5.png

Urey-Miller Experiment

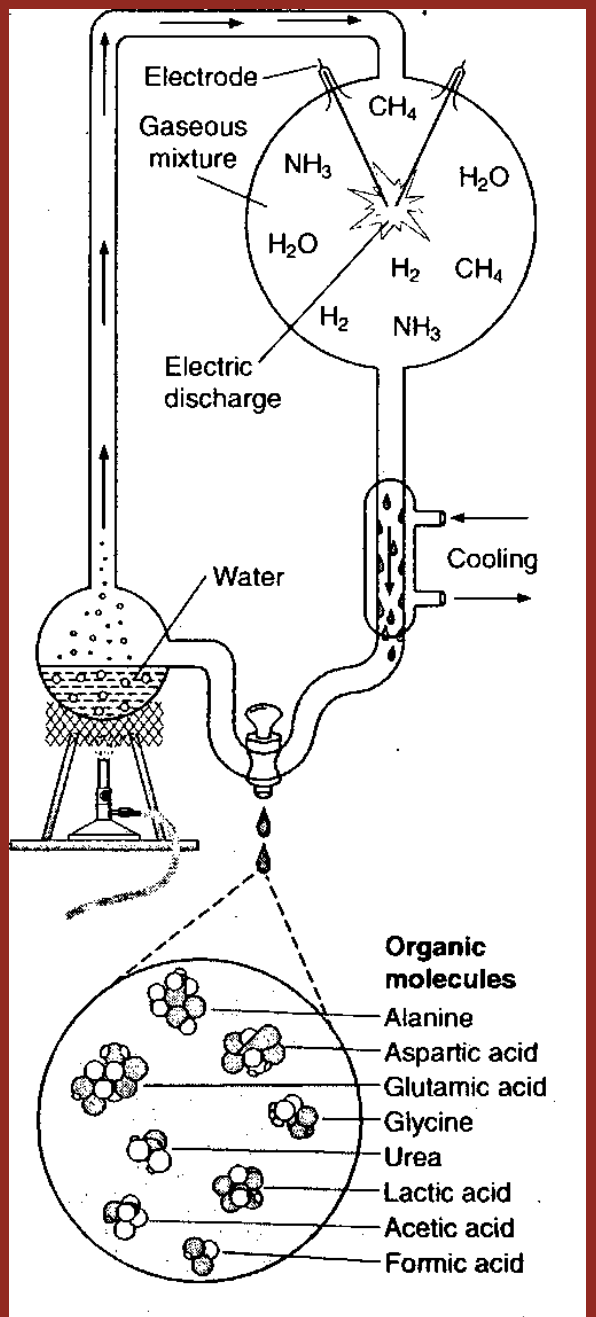


Fig. 2.7 Miller's apparatus and experiment

http://upload.vipulg.com/Zoology/759/Chapter2_files/Chapter2-8.png

Experiment designed to test the Oparin-Haldane Hypothesis.

•Findings embraced the Hypothesis.

Began with Hydrogen, Water, Ammonia and Methane.

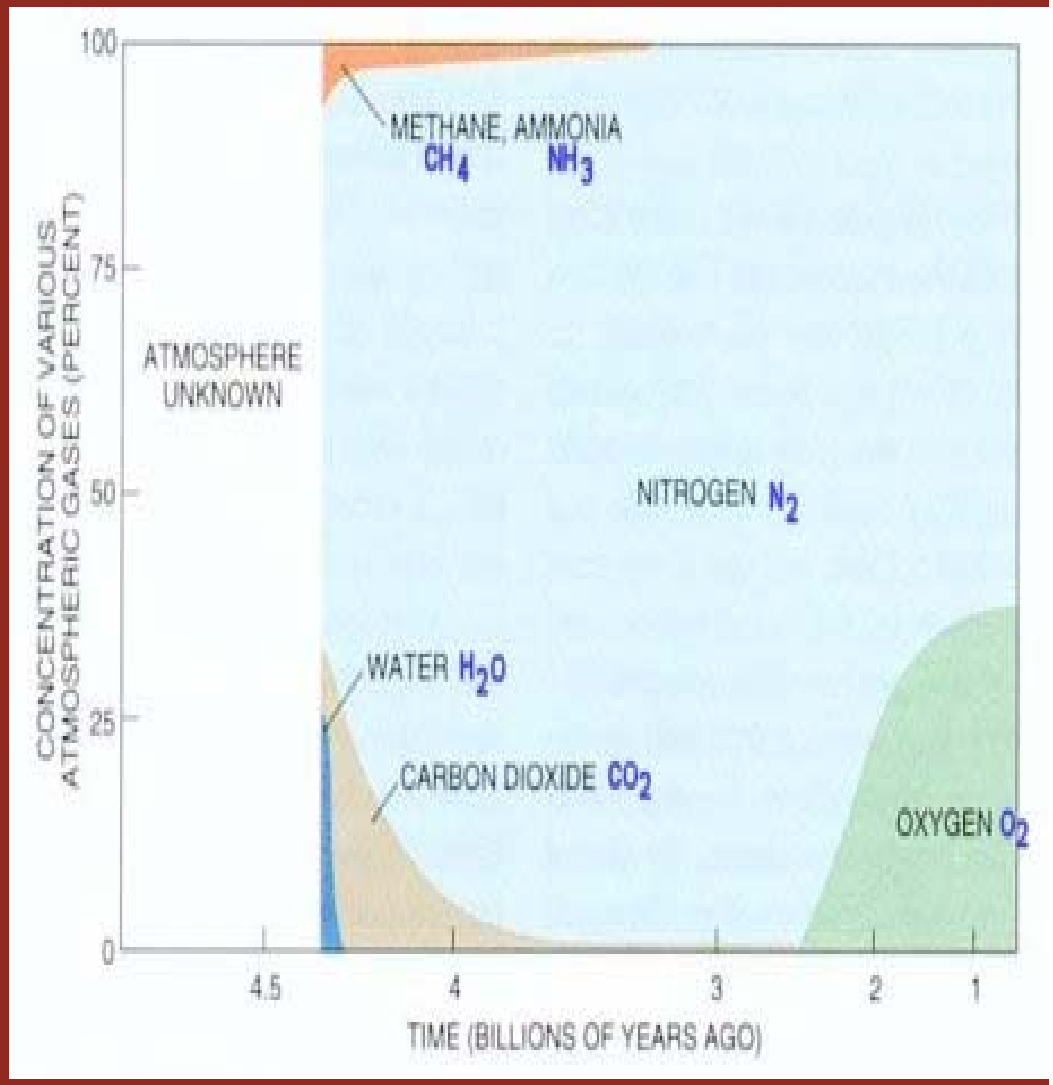
•End result: organic molecules

Atmosphere around the time of Earth's formation consisted of:

- **Hydrogen**
- **Water Vapor**
- **Ammonia**
- **Methane**

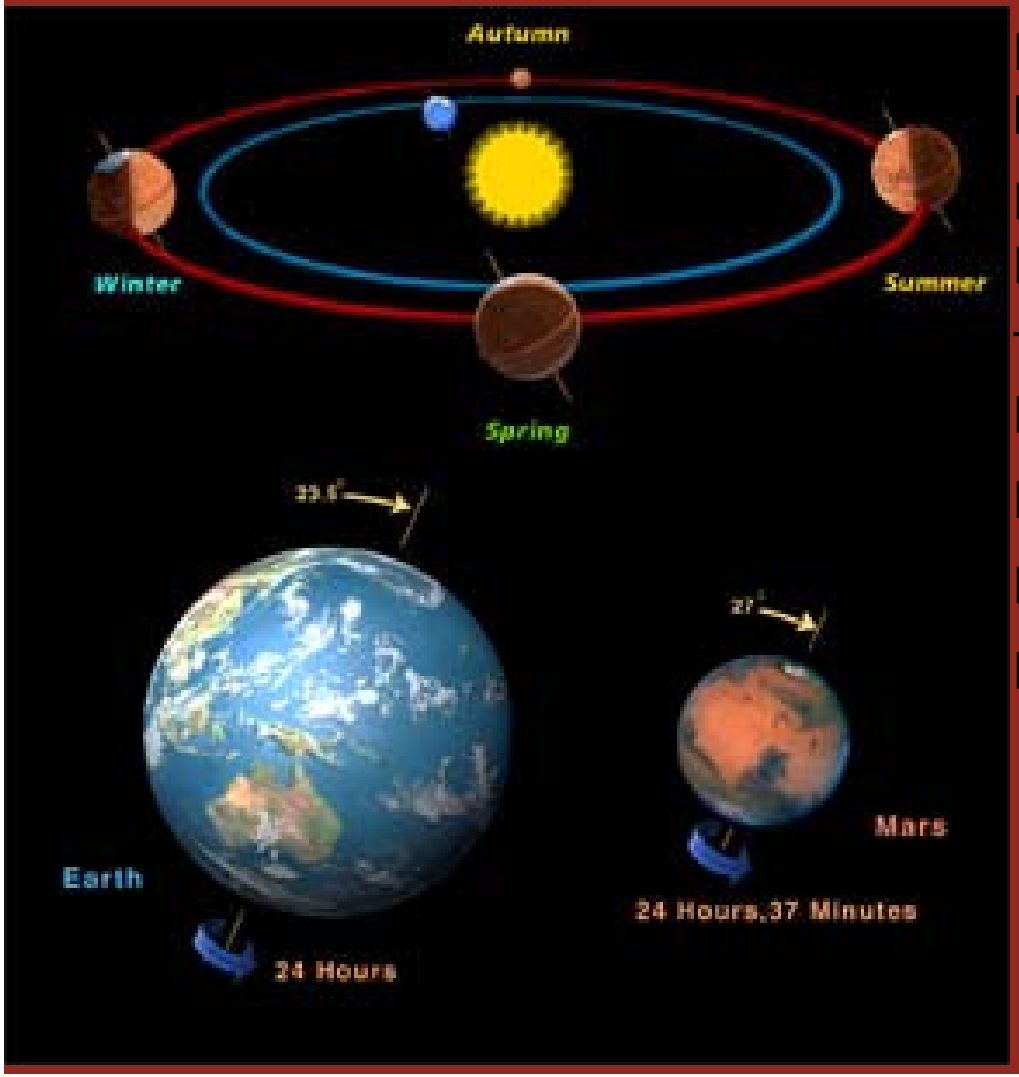
Spontaneous reactions occurred, resulting in abiotic synthesis.

- **Carbon**
- **Hydrogen**
- **Oxygen**
- **Nitrogen**
  - Atoms recombined to form the **first organic compounds**



http://karlrichard.files.wordpress.com/2009/07/i11-02-atmocompo.jpg?w=460&h=300

Mars & Earth
Similarities



Planet Rotation on axis: Mars=24.6 hrs Earth=24 hrs

Revolution around sun: Mars=1.88 yrs Earth=1 yr

Tilt of axis: Mars=25.19 ^{o} Earth=23.45^{o}

Earth-Water vapor Mars-Ice water

Moons. Mars: 2 Earth: 1

Both are Terrestrial Planets

http://www.cosmographica.com/flatfile/Mars_Romance/images/mars_earth_compared.jpg

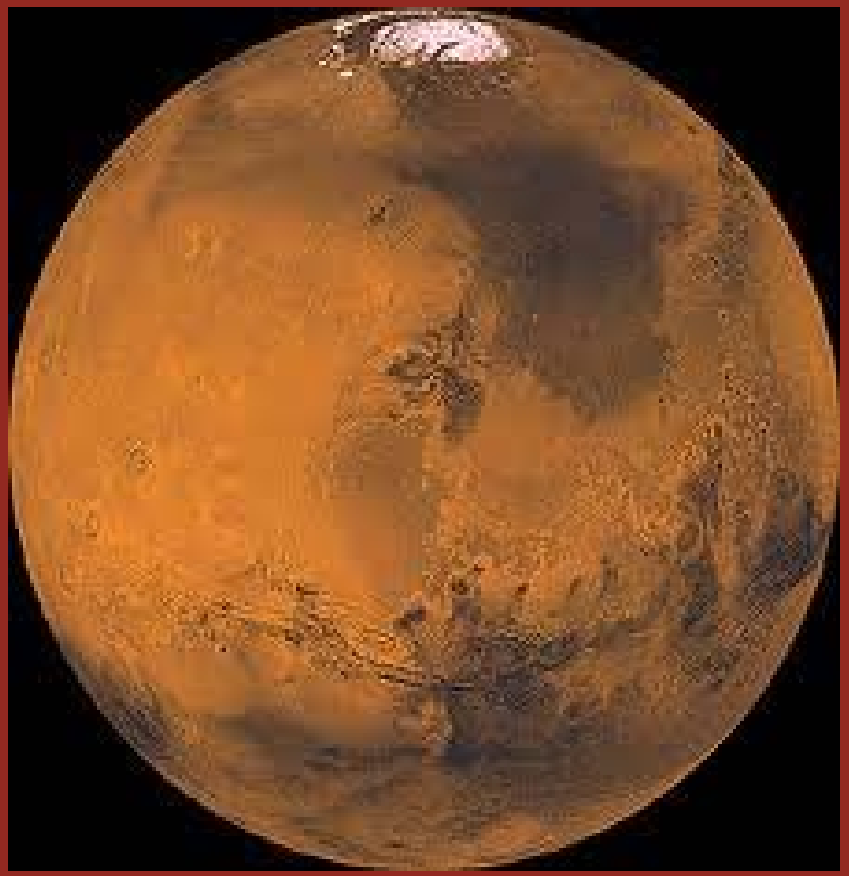
Viking Lander Mission: Why go to Mars?

Mission Goals:

•Obtain high resolution images of the Martian surface

•Characterize structure and composition of the atmosphere and surface

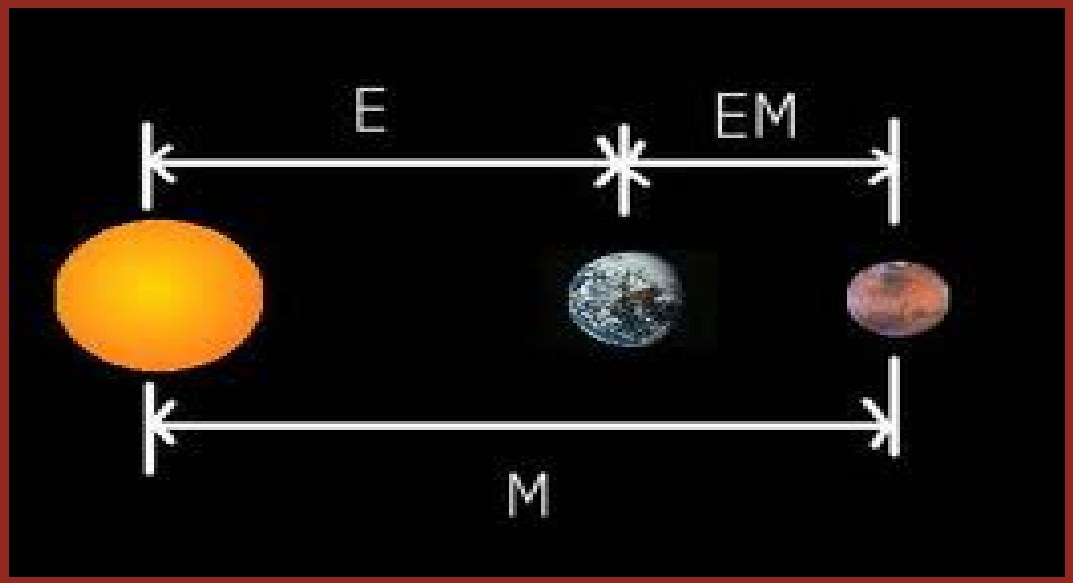
•Search for evidence of life



http://www.nwrc.usgs.gov/world/images/mars.gif

A Really Long Road Trip

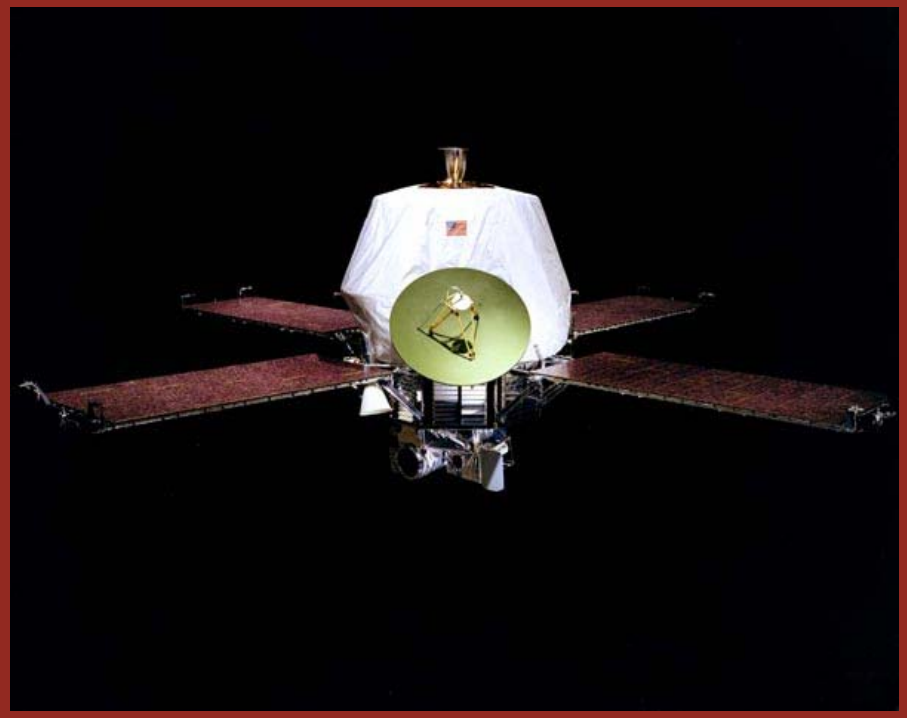
- Going to Mars took 5+ years of planning
- Viking spacecraft traveled for 10 months
- Viking 1’s trip took 333 days,
- Average distance from Earth to Mars, 36 million miles



http://www.astronomyforbeginners.com/images/diagrams/sunearthmars.jpg

Viking Orbiters

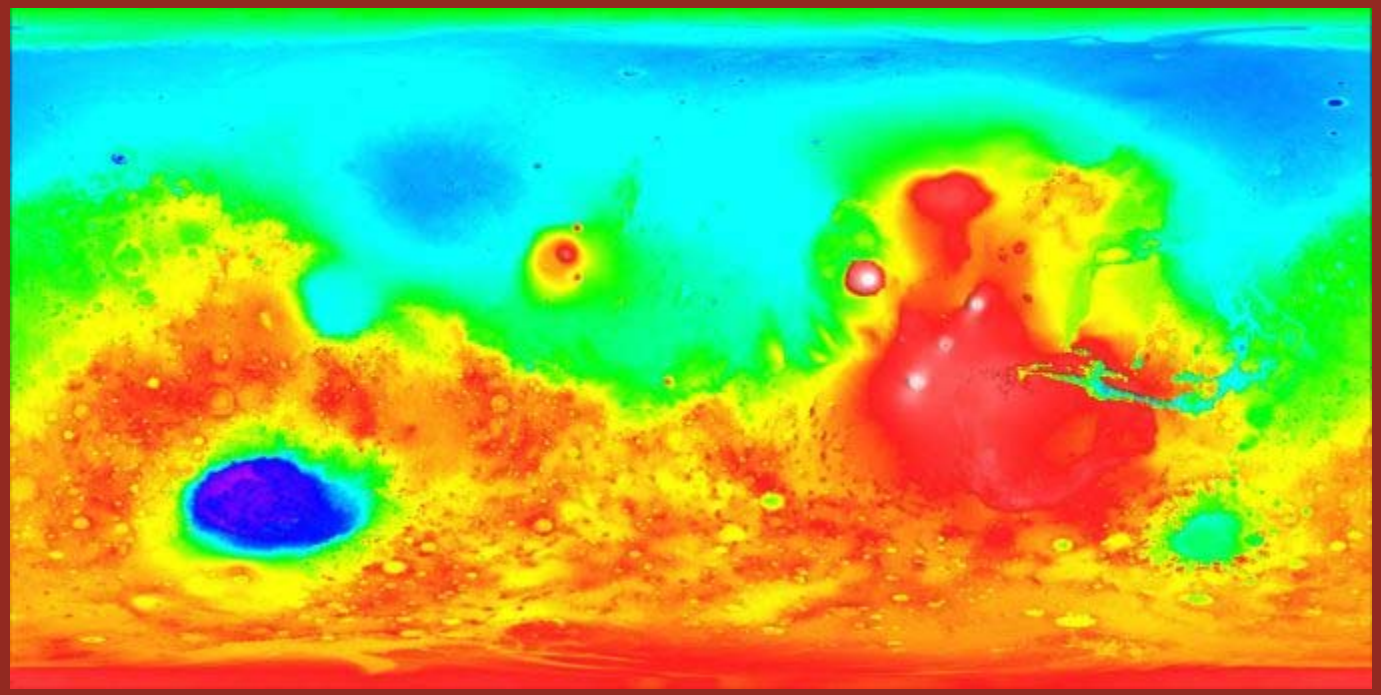
- Based on the design of the Mariner 9 spacecraft that helped in the exploration of Mars in 1971, the orbiters purpose was to survey Mars for suitable landing sites, study the atmosphere and relay information from the landers back to Earth



http://en.wikipedia.org/wiki/Mariner_9

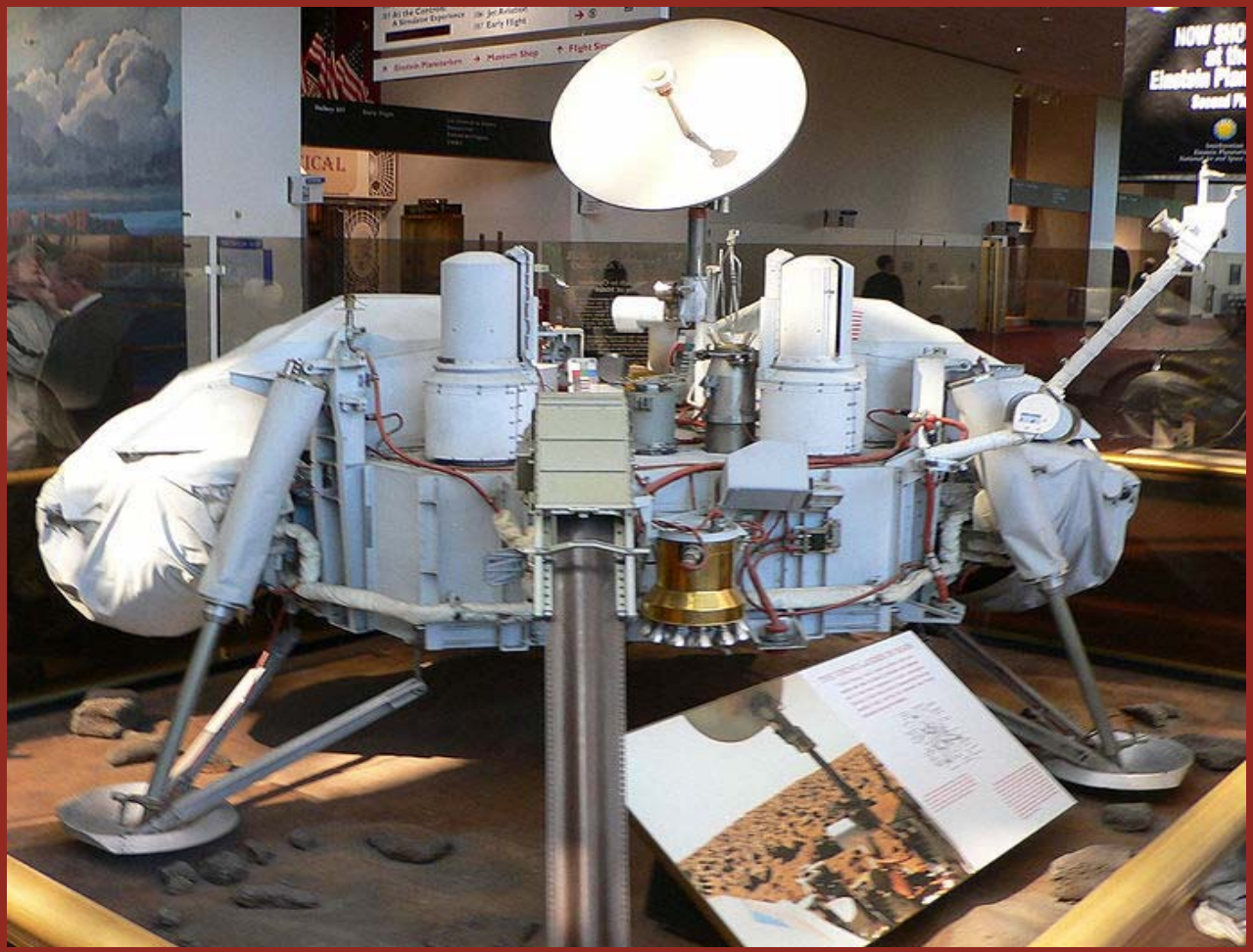
- The Viking Landers were attached to their orbiters in a way to isolate the landers from biological contamination on Earth

- After the landing sites were selected for their respective landers, the orbiters went on to survey Mars
- The Orbiters mapped 97% of Mars' surface in the 5 years they operated



http://images.astronet.ru/pubd/2006/01/05/0001210801/mars_fc_flat.jpg

Viking Landers



http://en.wikipedia.org/wiki/File:Viking_lander_model.jpg

Viking 1 Launch
August 20, 1975

http://www.jpl.nasa.gov/history/hires/1975/viking2_launch.jpg

Viking 1 and Viking 2

Identical ships: Orbiters and Landers

- Viking 1 left August 20, 1975 arrived on Mars June 19, 1976. Transmitted back until lost contact November 13, 1980
- Viking 2 left Sept. 9, 1975 arrived on Mars August 7, 1976. Transmitted back until lost contact due to battery death April 11, 1980

Where Are We Going To Land?

- The scientists looked for places to land the Landers that would be safe and productive

- Specific criteria, landing sites could not be "too high, too windy, too hard, too soft, too rough or too close to a pole” Carl Sagan *(Cosmos)*
- A billion dollar mission, failure was not an option!

Site Selection

- Sites were chosen to be a specific latitude but could be any longitude
- Why? Technology limits. Once the Lander separated from its orbiter the path could not be altered
- Latitudes were chosen that had multiple possible landing sites
- Carl Sagan mentioned in his chapter on Mars in his book *Cosmos* said, “the sites were safe but boring.”

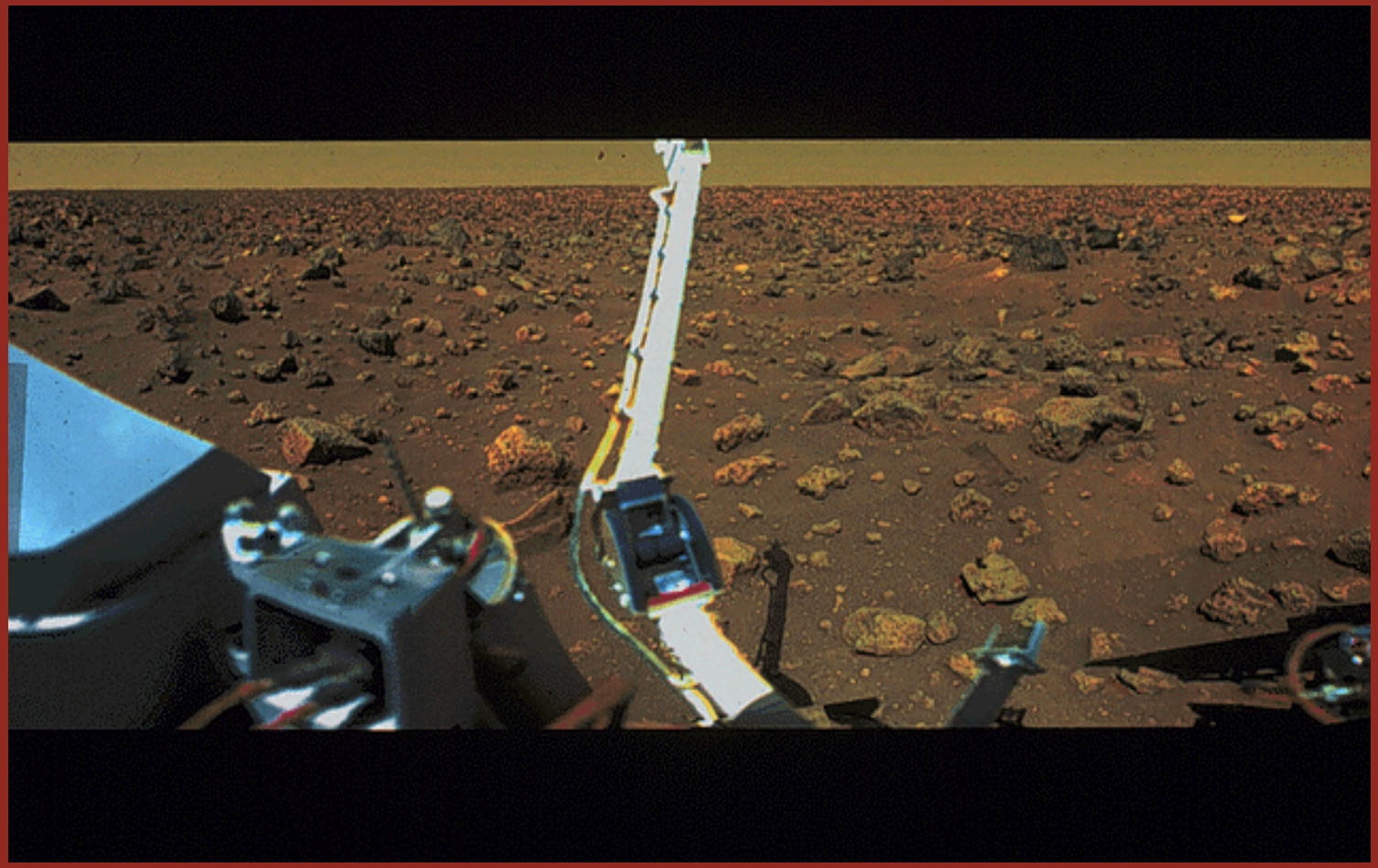
Viking 1 Landing Site

- Original plan was to land on July 4, 1976 on Mars surface
- This site was abandoned when orbital pictures showed a deep crater
- Team did not want a crash landing on the Fourth of July!

http://images.spaceref.com/news/2008/267568main_4698hires.s.jpg

- The team on Earth searched for a new site for the next three weeks.
- A site had to be found before Viking 2 arrived in Mars orbit.

Viking 1 Landing Site View



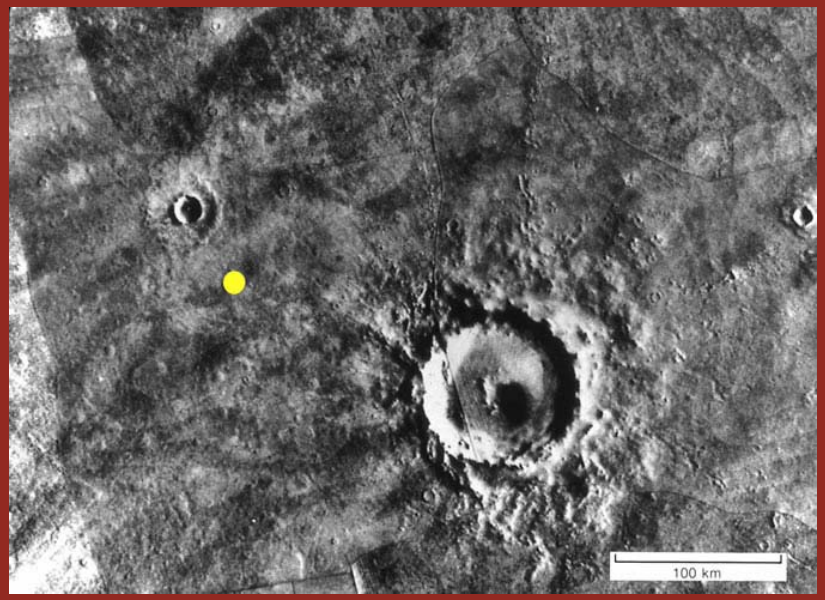
Viking\Mars photos\panview Viking 1 landing site NASA press release, July 20, 1976

Viking 2 landing site

Originally Viking 2 was supposed to land at Cydonia which is near “The Face of Mars.”

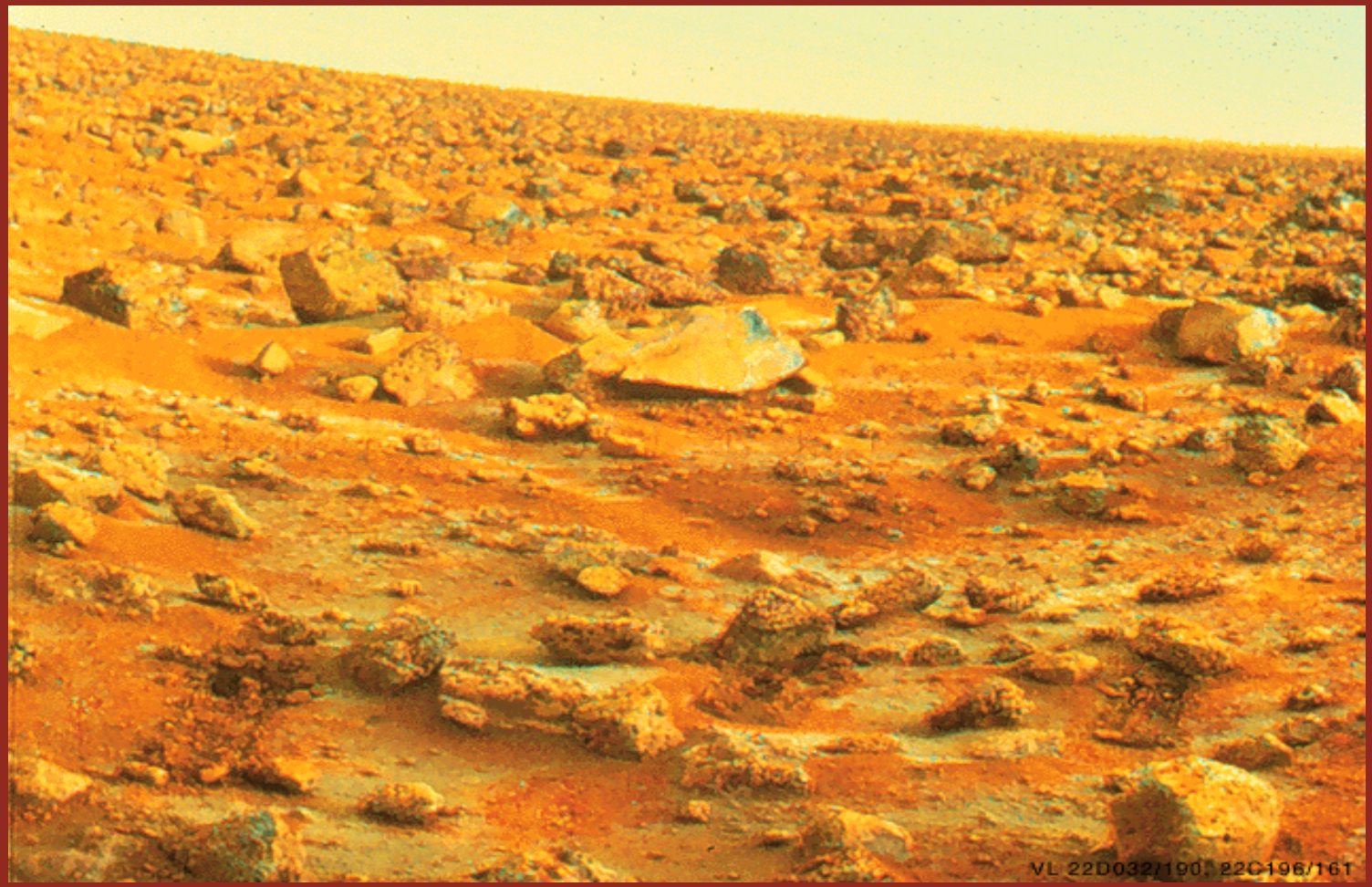
http://media.weirdworm.com/img/stories/the-history-of-3-bizarre-images/face.jpg

The new site became Utopia Planitia at 44 North which was then searched for traces of water.



http://www.lpi.usra.edu/publications/slidesets/stones/images/stones11.jpg

Viking 2 Landing Site View

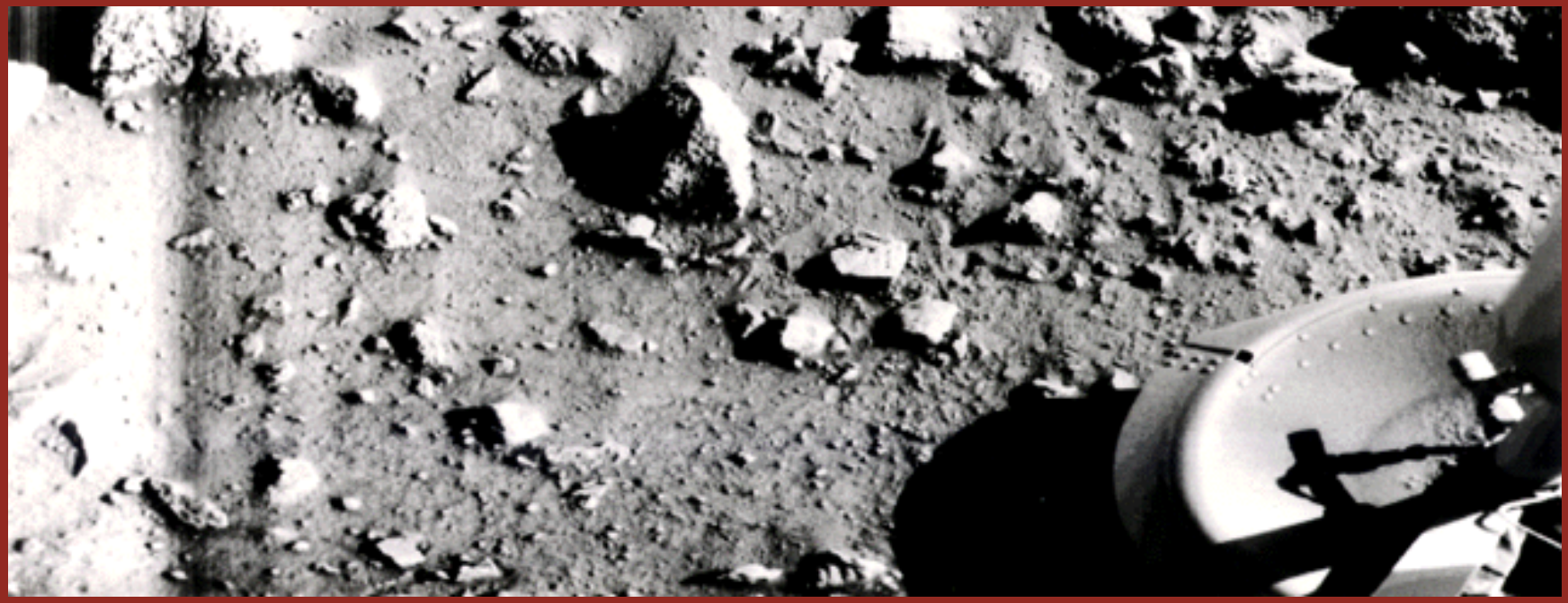


Viking\Mars photos\permafrost at Viking2 landing site Viking Lander high resolution Washington University, St. Louis.gif

A First Look at Mars

Viking 1 sent back amazing pictures.

This is the first picture sent of the surface



http://www.nasaimages.org/luna/servlet/detail/nasaNAS~5~5~23140~127274:First-Mars-Surface-Photo

Successful Landings

- Viking 1 landed on July 20, 1976
- Viking 2 landed September 3, 1976
- It was then time to start the experiments on Mars
- The search for Martian Life was ON!

Viking Lander Experiments

- 3 Biological Experiments conducted on both Viking I and II
  - Gas Exchange
  - Labeled Release
  - Pyrolytic Release

- Organic Experiments also conducted
  - Using Gas Chromatograph-Mass Spectrometer

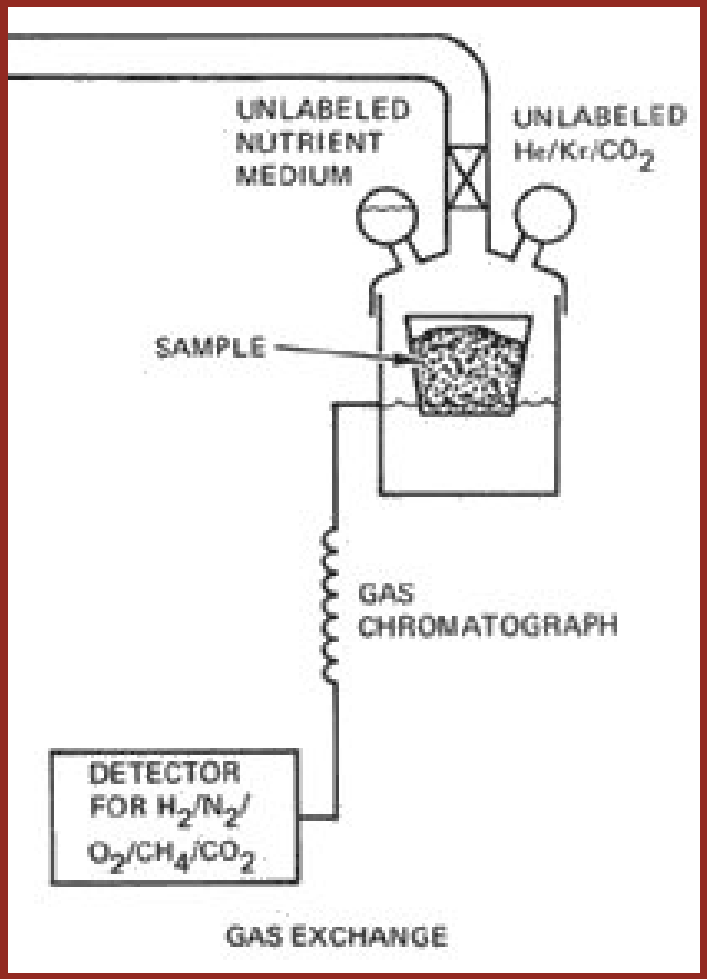
- Purpose: To characterize the structure and composition of the atmosphere and surface, and most importantly search for evidence of life.

http://nssdc.gsfc.nasa.gov/planetary/viking.html

Gas Exchange Experiment (GEX)

- Organic Broth “Chicken Soup” added to soil sample, then incubated in simulated Martian atmosphere

- Gases emitted would then indicate organisms coming to life – Metabolism Change

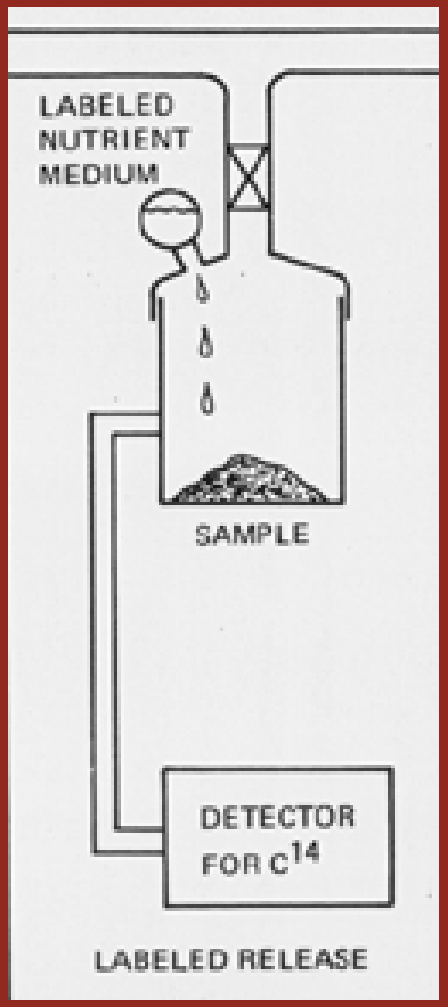


http://www.daviddarling.info/encyclopedia/V/VikingGEX.html http://cmex.ihmc.us/CMEX/data/MarsEssy/life/life.htm

Labeled Release Experiment (LR)

- Adds water and organic compounds to soil sample which is then incubated

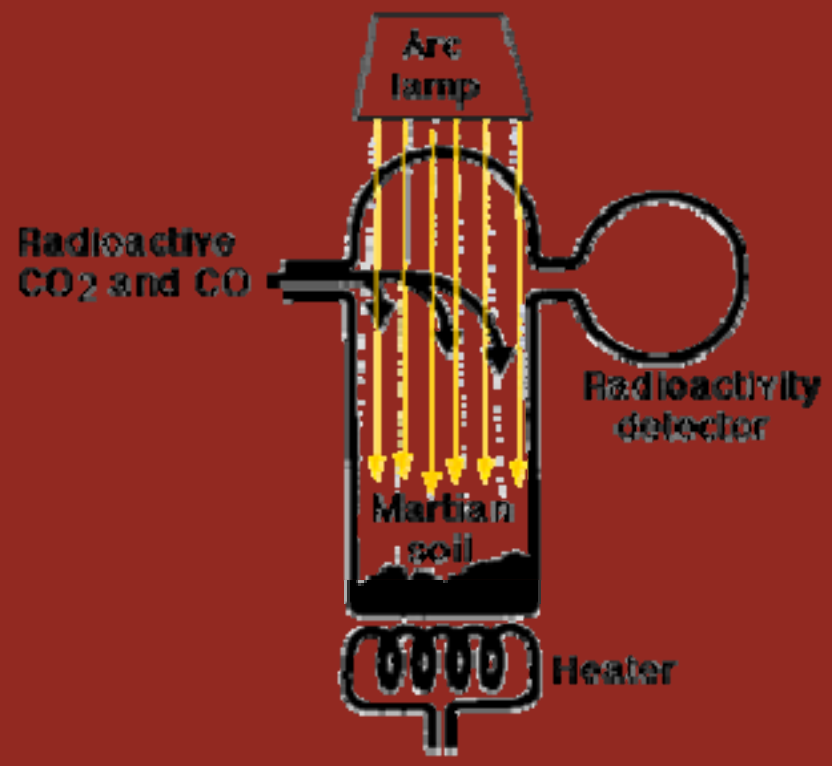
- Then detects carbon dioxide and other gases released by microorganisms as a result of metabolic activity



http://www.daviddarling.info/encyclopedia/V/VikingLR.html
http://cmex.ihmc.us/CMEX/data/MarsEssy/life/life.htm

Pyrolytic Release Experiment (PR)

- Only experiment conducted using actual Martian surface conditions (No addition of water or organic compounds)
- Soil sample incubated under artificial sun, then heated to break down organic material, gases then passed through Carbon 14 detector to see if any organisms had ingested labeled atmosphere

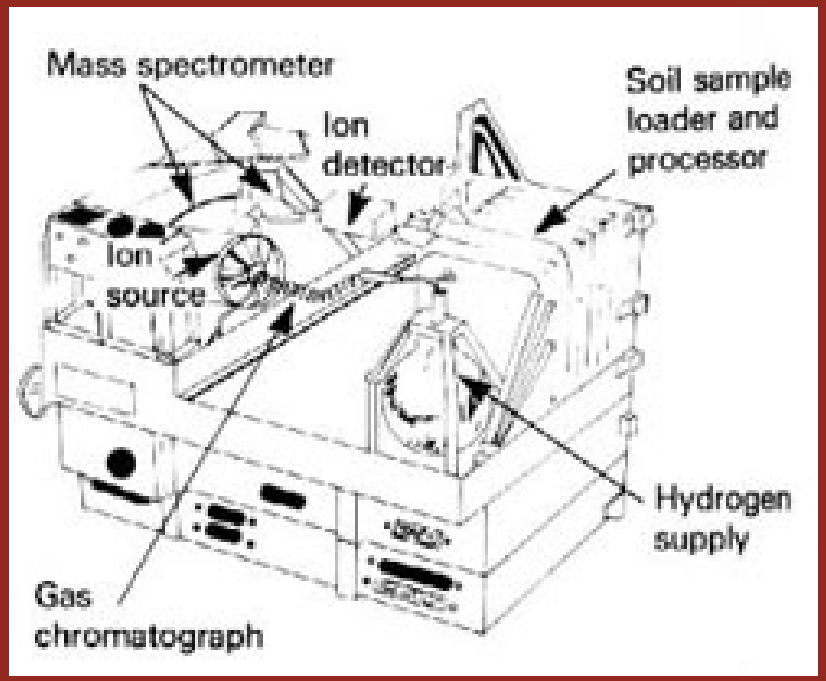


The Pyrolytic Release (PR) experiment

http://www.daviddarling.info/encyclopedia/V/VikingPR.html
http://cmex.ihmc.us/CMEX/data/MarsEssy/life/life.htm

Gas Chromatograph-Mass Spectrometer (GCMS)

- Analysis of small concentrations of organic compounds found in soil
- Gas Chromatograph separates volatile gases
- Mass Spectrometer analyzes composition



http://www.daviddarling.info/encyclopedia/V/VikingGCMS.html

Biological Experiment Results

Expected Results if Terrestrial life had been detected

	Response for Sample	Response for Heat-Sterilized Control
GEX	O2 or CO2 emitted	None
LR	Labeled gas emitted	None
PR	Carbon detected	None

Actual Results

	Response for Sample	Response for Heat-Sterilized Control
GEX	O2 emitted	O2 emitted
LR	Labeled gas emitted	Non-biological
PR	Carbon detected	Carbon detected

= Indicates non-biological (chemical) processes at work

http://cmex.ihmc.us/CMEX/data/MarsEssy/life/life.htm

GCMS Results

The GCMS failed to detect organic compounds

- Due to limited sensitivity and mechanical reliability
  - Flight Constraints
  - Pressure Limits

- Tests were not conducted before launch to avoid contamination

http://mars.spherix.com/2000SPIEFinal.html

Chemistry or Biology Debate

- The biological experiments that were conducted in 1976 produced positive results of living organisms in Martian soil, except the Labeled Release Experiment which had controversial results
- Gas was detected with this experiment but at the time it was believed that the results were that of a chemical process, not biological, therefore no results determined.
- Explanations of experiments and results are constantly in a tug of war between chemical and biological by scientists involved in the Viking Projects as well as others using the Mars experiments on organisms found in Antarctica and Alaska and comparing those results.
- Debate of chemical or biological continues

  http://www.space.com/scienceastronomy/viking_labeledrelease_010905-1.html

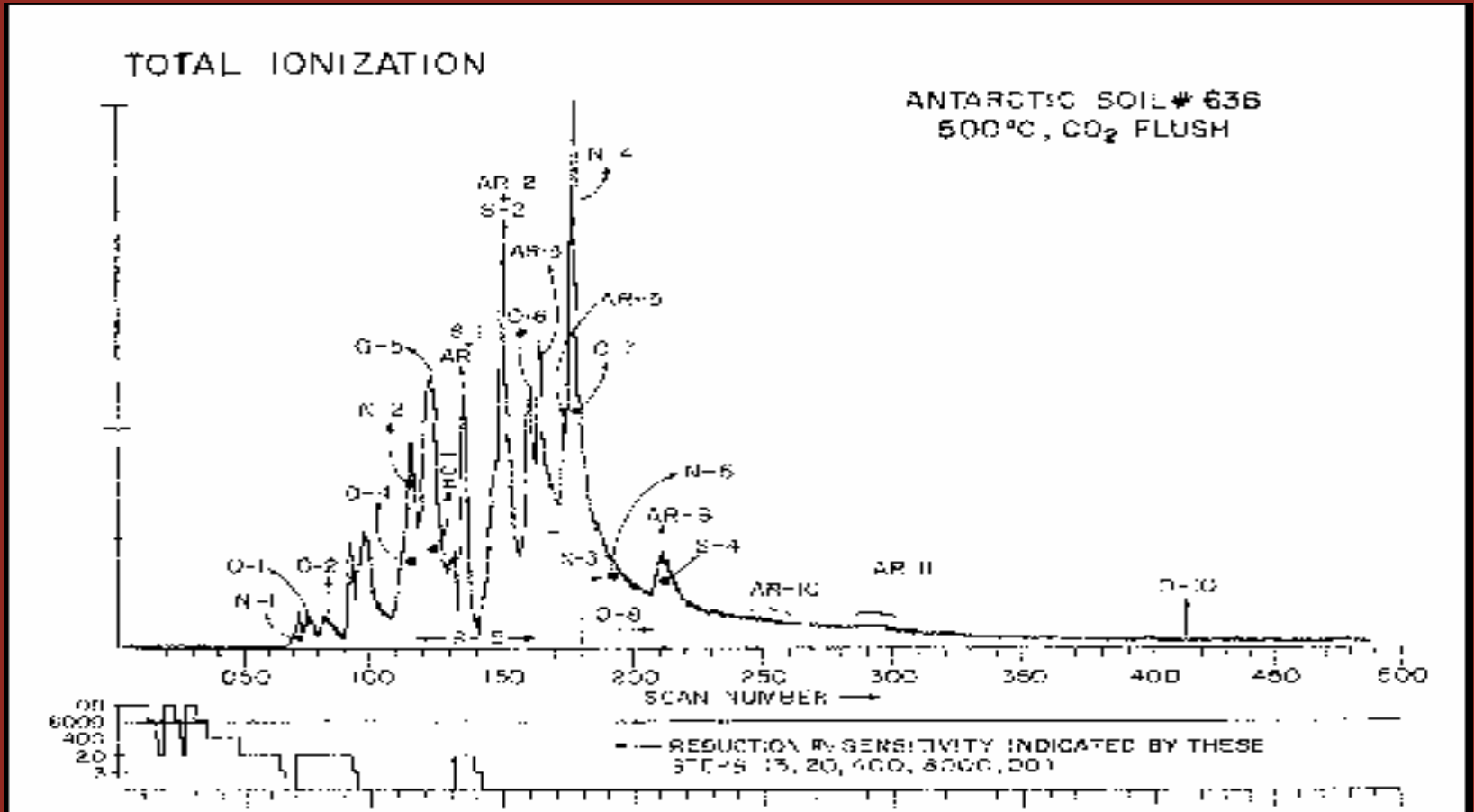
Instrument Flaws

- In 2000 a it was brought out that the instruments sent to Mars that were used in the biological experiments were proven in tests on Earth to have missed significant amounts of organic matter in the soil.

http://www.spacedaily.com/news/mars-life-00i.html

- The flaws in the instruments have added to the reasons that the Labeled Release Experiment failed to detect living organisms in the soil on the surface of Mars, continuing the disagreement.
- Due to meteorite activity, interplanetary dust and photochemical synthesis of atmospheric gases, Mars as well as space, should be plentiful with organic material
- Were there really flaws in the pre-Viking experiments?

Chart of Organic Material Found in pre-Viking experiments



Credit: Biemann K., et al., JGR, 82, 28, 4641, 1997.

http://mars.spherix.com/2000SPIEFinal.html

Methane: Sign of Martian Life

Methane on Mars could have come from bacteria as well as by inorganic processes – detected in 2003-2004 remotely

•Scientists have experimented with possible sources of methane gas on Mars:

-Meteorites
-Volcanic activity
-Organic matter in the soil
-Mineral olivine (abundant on Mars) reacting with H_2O and CO_2
http://www.dartmouth.edu/~news/releases/2005/06/07a.html

•Meteorites being the main source of methane on Mars was ruled out in British experiments, living organisms is still at the top of the list as a source of methane

•Raising hopes of those behind the biological proof of life on Mars that the gas might be generated by living organisms
http://www.physorg.com/news179499648.html

Hiding Places for Life on Mars

- Evidence of salty bodies of water throughout the surface of Mars are an “excellent site” for a life friendly environment much like that of Earth. If there was life on Mars, the rocks that were resident in the salty water beds would be preservers of biological signs.

  http://www.space.com/scienceastronomy/opportunity_sea_040323.html

- Strong evidence shows that Mars does indeed have relatively recent volcanic activity, which will continue for millions of years. “This new discovery is a potential for ongoing thermal and water sources to sustain or start an environment compatible with life than can still be present today.”

  http://www.space.com/scienceastronomy/solarsystem/mars_volcano_011113.html

Biological Explorations Since Viking

2003 Mars Express Orbiter/Beagle 2 – conducted by the European Space Agency and NASA

- Beagle 2 was designed to perform biological and chemical experiments
- Beagle 2 failed to land safely on the surface of Mars again keeping Earth from knowing if there is life on Mars

2007 – 2008 Phoenix Scout - NASA conducted Scout Program

- Designed to study water history and habitability potential of Mars
- Equipped with a robotic arm to dig in to the terrain in search of water, organic matter and environments suitable for living organisms
- H_2O confirmed but nothing biological detected

Further Scheduled Explorations

2009-10: **Mars Science Laboratory (USA**): a roving long-range, long-duration science laboratory that will be a major leap in surface measurements and pave the way for a future sample return mission.

Beyond 2009 (USA/International): NASA plans additional science orbiters, rovers and landers, and the first mission to return samples of Martian rock and soil to Earth

2011: **Mars Scout 2 (USA**). A mission succeeding and extending the 2007 Mars Scout, Phoenix.

2014: **Mars Sample Return Lander (NASA, France, Italy**): Under study for launch in early 2014. Possible first sample return mission. To arrive at Mars in late 2014, launch from Mars early 2015, and return to Earth in late 2016.

2016: **Mars 2016 (USA, international)**: Another sample return mission, or orbiters, landers, rovers and possibly man on Mars.

Summary of Viking Experiments

- In the 1970's NASA sent explorations to Mars in search of Life.
- Two missions, Viking 1 and Viking 2 took land samples looking for organic material in separate parts of the planet along with orbiters to survey the planet from it's orbit.
- O_2, CO_2 were detected using the Gas Chromatograph and Pyrolytic Release Experiments. GCMS results were negative. Label Released results are still in a tug of war.
- Research is underway to develop more sensitive GCMS instruments for detecting organic material in severally isolated locations on Earth and in turn be used to detect life on Mars.
- The debate over organic material is still ongoing and future trips to Mars are in the works to hopefully settle the debate.