FROM EXTREMOPHILIC MICROBES TO POSSIBILITIES OF LIFE

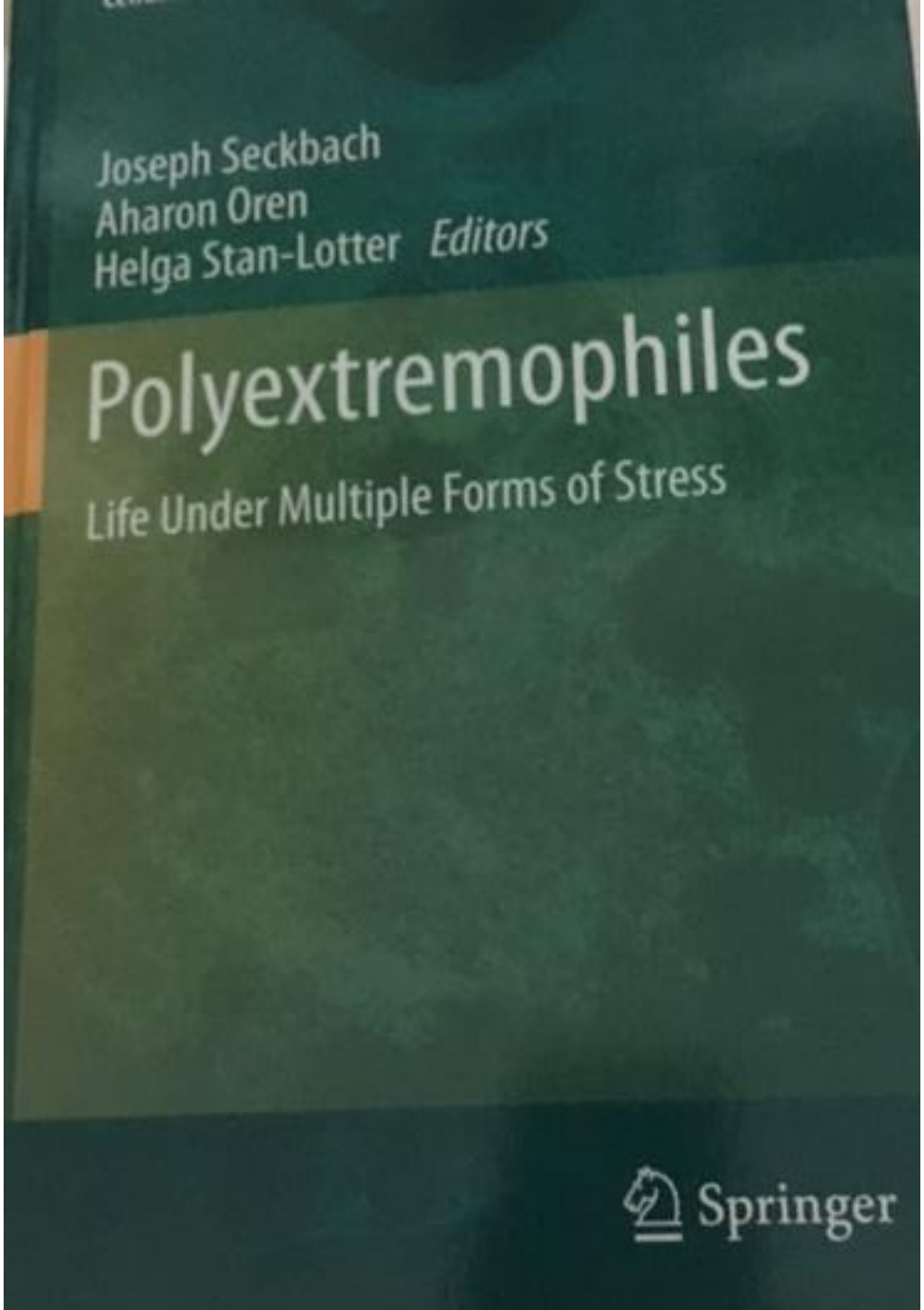
Joseph Seckbach

Hebrew University of Jerusalem

joseph.seckbach@mail.huji.ac.il

Preformed in **Barcelona, May 12, 2017**)


Contents
APRIL 2017


Joseph Seckbach
Aharon Oren
Helga Stan-Lotter Editors
Polyextremophiles
Life Under Multiple Forms of Stress
Springer

Hydrothermal Vents on Enceladus [satellite of Saturn] release hydrogen Molecules -Hint at Life Beyond Earth

The Cassini spacecraft found chemicals associated [H_2] with life-giving hydro-thermal activity.

New solar system found to have 7 Earth-size planets

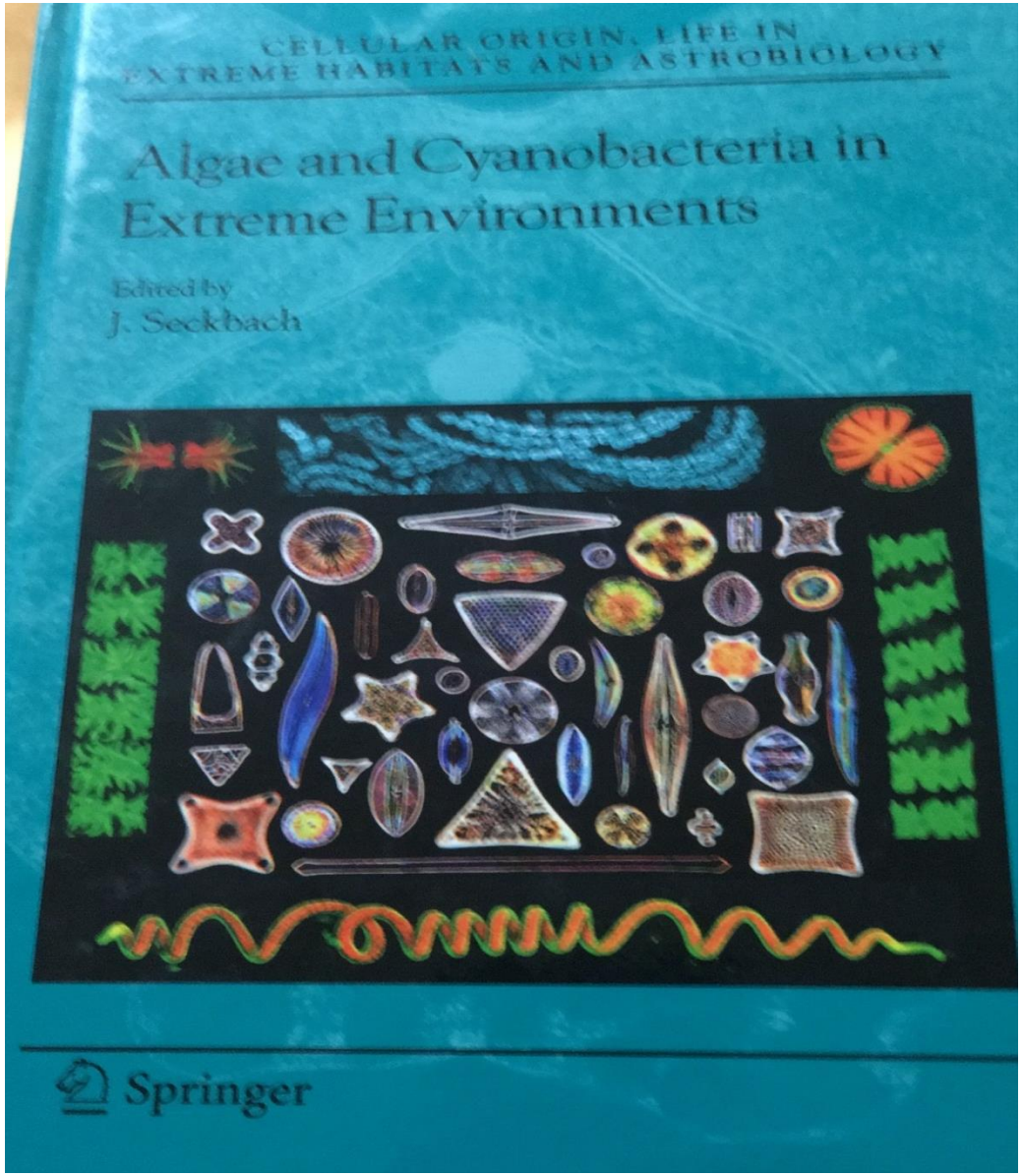
Three may even orbit in the 'Goldilocks' zone

The distance to this newly found system is ~ 40 light years.

BY ASHLEY YEAGER – SCIENCE MAGAZINE. **FEB 23, 2017**

Algae and Cyanobaeteria in the Extreme Environments

Edited by J.Seckbach



Hydrothermal Vents on Enceladus [satellite of Saturn] release [H_2] hydrogen Molecules -Hint at Life Beyond Earth.

The Cassini spacecraft found chemicals associated [H_2] with life-giving hydro-thermal activity.

[Discover Mag. APRIL 20, 2017]

AMONG THE poly-EXTREMOPHILES SURVIVING IN HARSH CONDITIONS ARE:

HALOPHILES and hyper saline environments (salt lovers)

TEMPERATURE (high and low)

PH RANGES (acidophilic and alkaliphiles)

PRESSURES Barophiles (living under high pressure in deep sea vents) deep life on Earth. Microorganisms found 633 m. below sea floor and under 2833 m of ocean waters (in N.W. USA).Microbial life in deepest spot on Earth (Mariana Trench)

CAPNOPHILES [organism loving CO2, such as *Cyanidium caldarium]*

OSMOPHILES (surviving in high sugar environment)

ANAEROBIC HABITATS lacking oxygen

XEROPHILES (living in hot desert with little water)

ENDOLITES-dwelling on rocks and caves.

TOLERATES RADIATION (*Reinococcus radiodorans*)

MISCELLANEOUS – microorganisms survival

Among extremophiles are: Archea-bacteria-Eukaryotes as fungi-Lichen-spores – worms-animals

Bacteria spores of >40 million year old - found in Earth.

Microorganisms lasted in outer Space

Mars possible survival of microorganisms inside rocks (play the song of Green Fields)

PLACES ON EARTH FOR EXTREMOPHILES

Hypersaline lakes

Arid region

Deep sea

Acidic sites [thermo acidic lakes] Rio Tinto river (ES); Yellowstone NP, Antarctica,

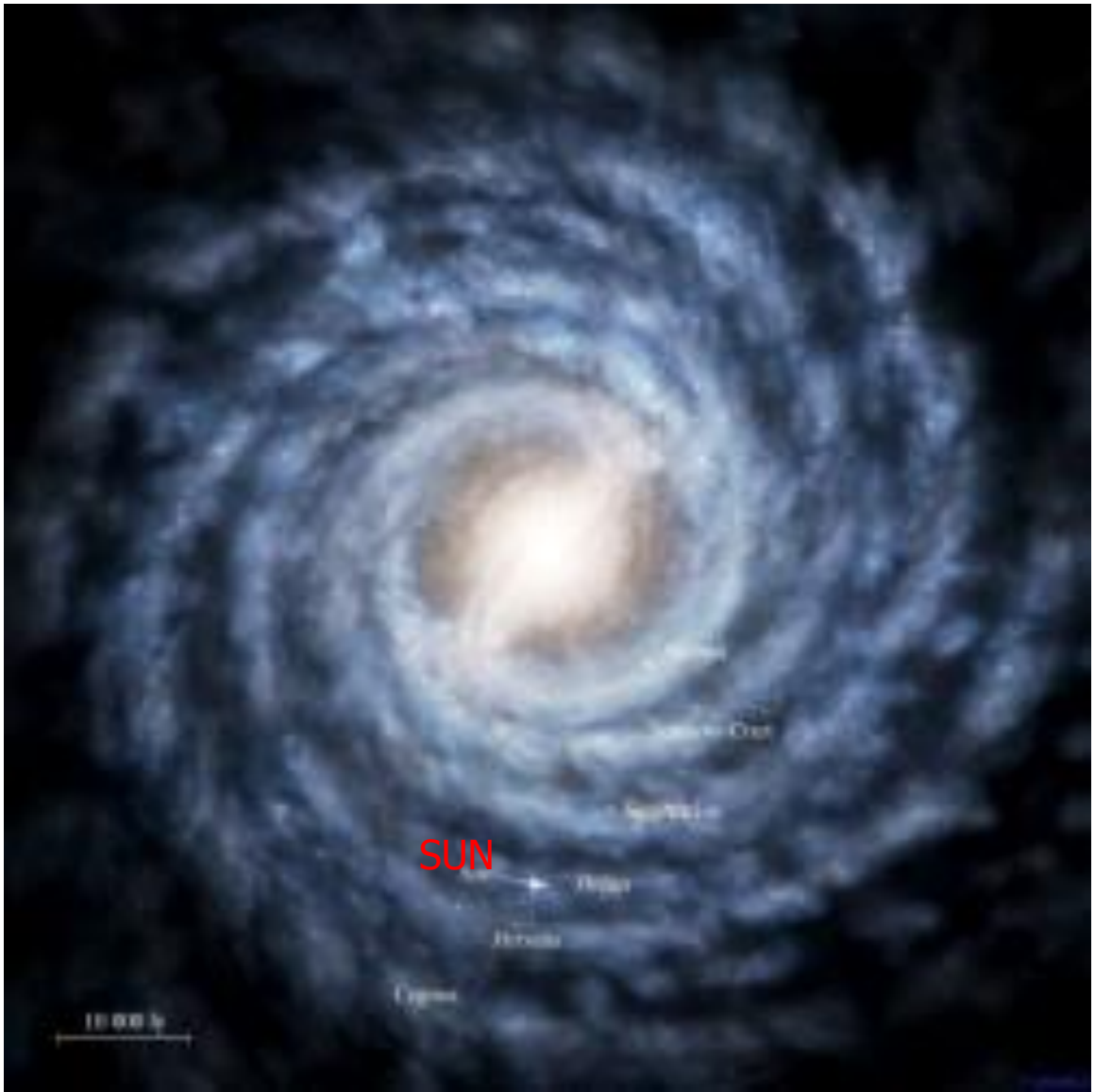
Cold and dry Polar region and permafrost

EXTREMOPHILES COULD SERVE POSSIBLE AS MODEL OR FOR EXTRATERRESTRIAL LIFE.

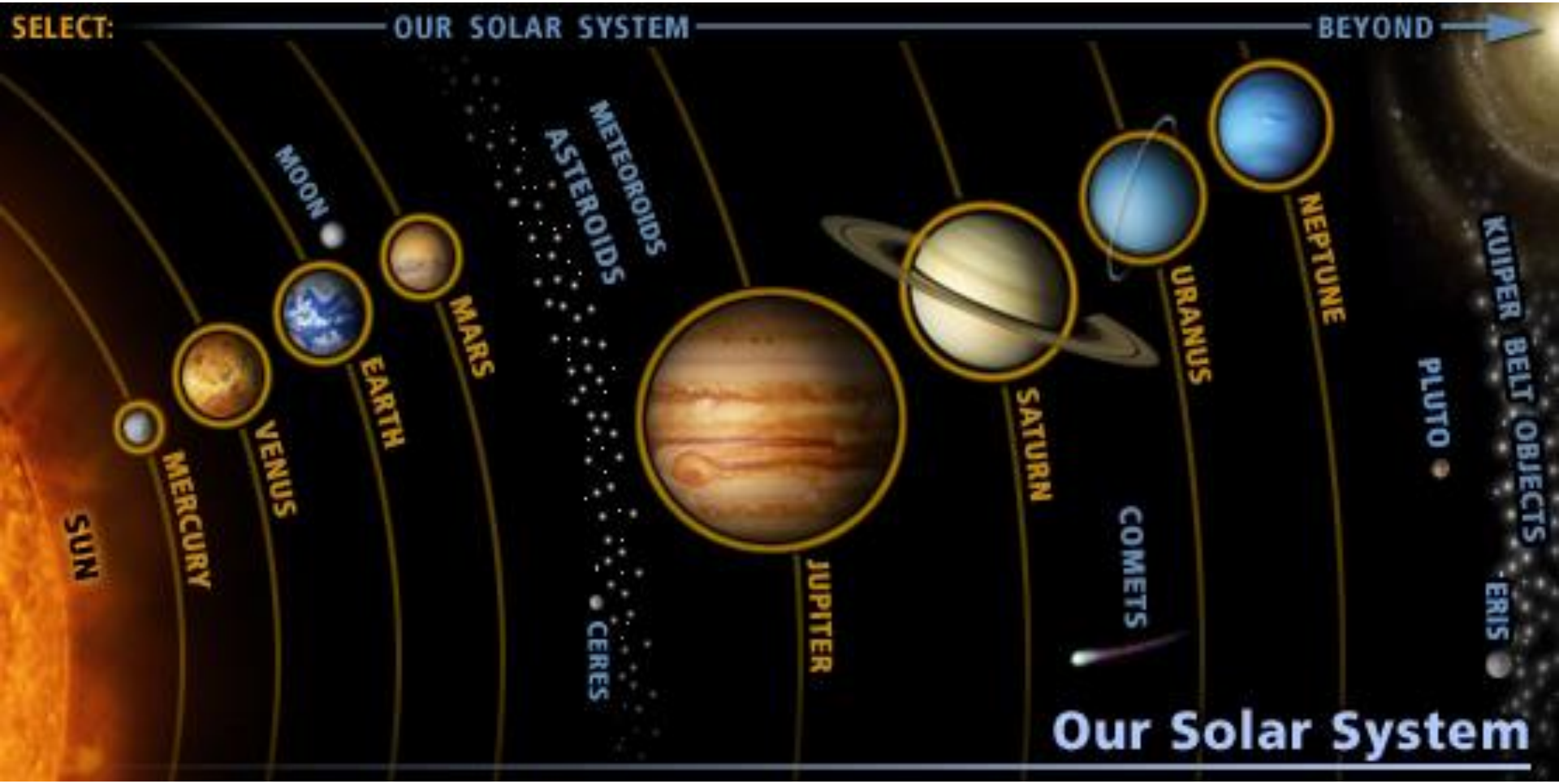
POMPEII WORMS-Alvinella pompejana, the Pompeii worm, is a species of deep-sea polychaete worm (commonly referred to as "bristleworms"). It is an extremophile found only at hydrothermal vents in the Pacific Ocean, discovered in the early 1980s off the Galápagos Islands by French marine biologists.

ANTARCTICA KRIL (crustacean)

Our Galaxy



SOLAR SYSTEM



*THE EXTREMOPHILES & POLYEXTREMOPHILES



* **TEMPERATURE** [High-Low]
* **pH EFFECTS**

(**Acidophiles** Vs. **Alkaliphiles**)

* **PRESSURES**

(Barophiles, Piezophiles)

* **UV EFFECTS**
* **LIFE IN GASES** (CO_2, NH_3, CH_4)

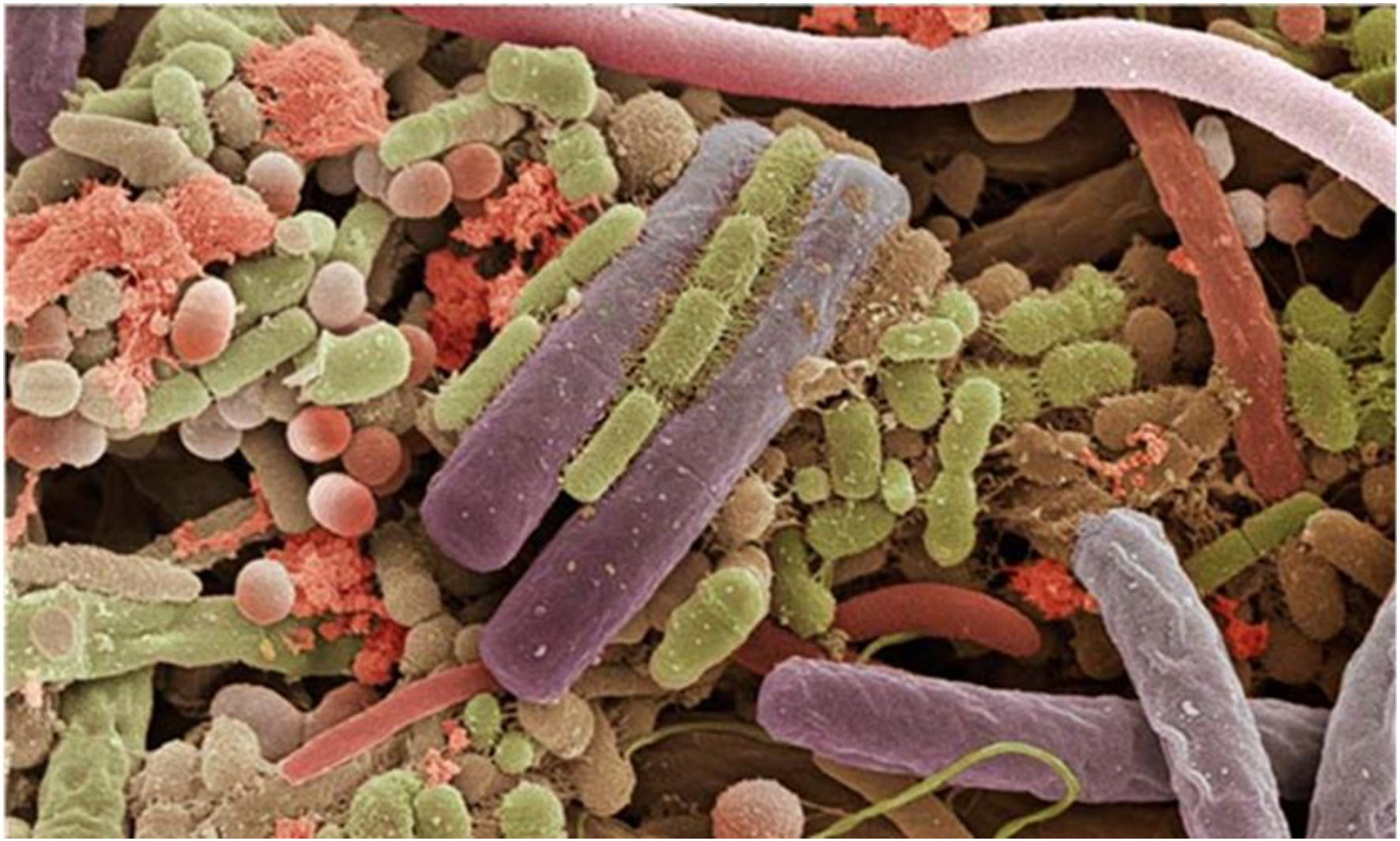
- **NEW DISCOVERY OF UNDERSURFACE BACTERIA**

- **The discovery of solitary little CRITTERS DEEP BENEATH EARTH'S SURFACE. A community of bacteria was found 2.8 kilometers below ground in a gold-mine and it lives completely alone and completely independent of any other life forms. It also subsists without sunlight or oxygen. They represents the kind or organism that could survive below the Earth surface or some satellits.**

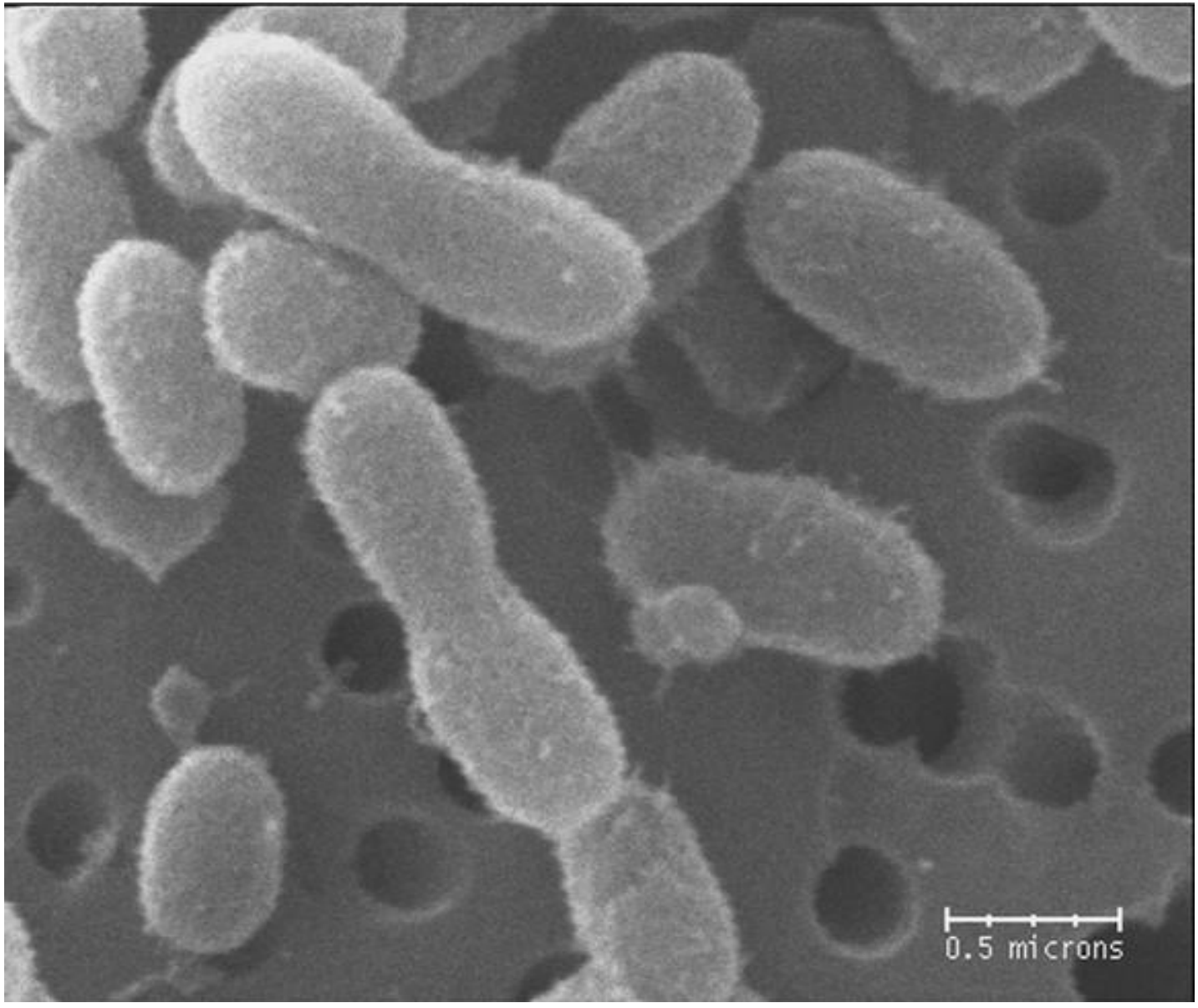


Dead Sea (Israel) where halophiles are growing

THE MICROORGANISMS WORLD



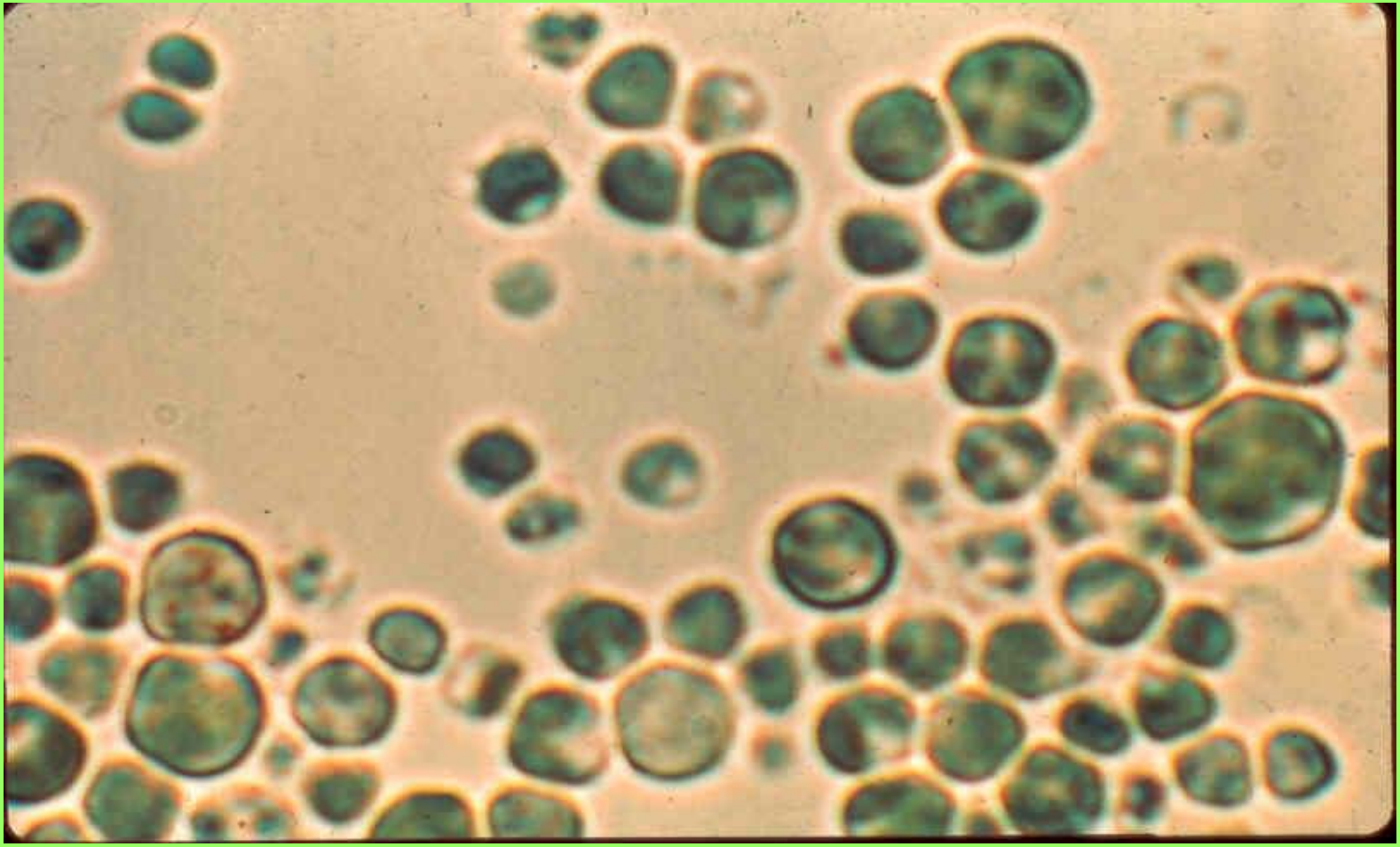
Bacteria revived after over 120,000 years from Greenland frozen glaciers




at Yellowstone Hot Spring



Galdieria sulphoraria
[red algae]



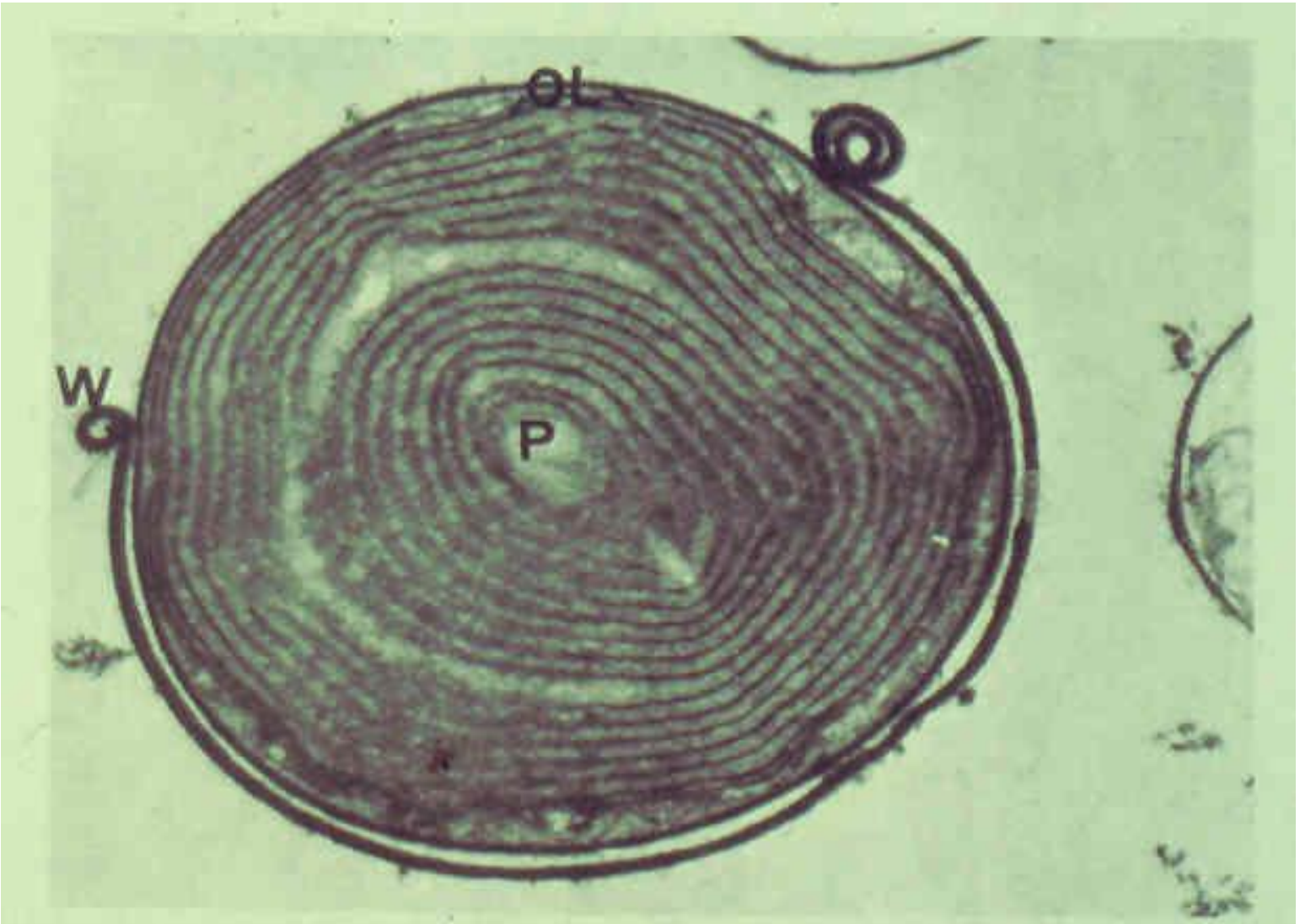


FIGURE 9. The chloroplast (P) of this cell (from strain B culture) occupies most of the cytoplasm volume and contains 15 concentric thylakoids. The scroll-like wall (W) occurs as the cell reproduces (see FIGURES 2, 3, as viewed by the SEM). The outermost lamella (OL) runs parallel with the plastid envelope. ×27,500. From Seckbach [22] with permission from the *Israel Journal of Botany*.

shrimps that lives in hydrothermal vents

- Live in hydrothermal vents (areas of hot water) in the Caribbean.
- 

Tardigrades [water bears] Multi-segmented Extremophilic microbes













Tardigrade-[water bear]

a Multicellular

Extremophile;Tolerate

90C to – 272C

(Horikawa et al 2008, 2012; Schulze-Makuch&Seckbach 2013)

TARDIGRADES – Water Bears- FEATURES,

TARDIGRADES – Water Bears- FEATURES,

Minute animals of 4 segments, length < 1 mm.

Sent to space and survived out of Earth atmosphere [the only organism resisted in space without protection]

Unique distribution in land and waters

Resist cryobiosis of minus 272C and up to plus 180C.

Tolerates vacuum of space.

Could resist the temperature of Mars

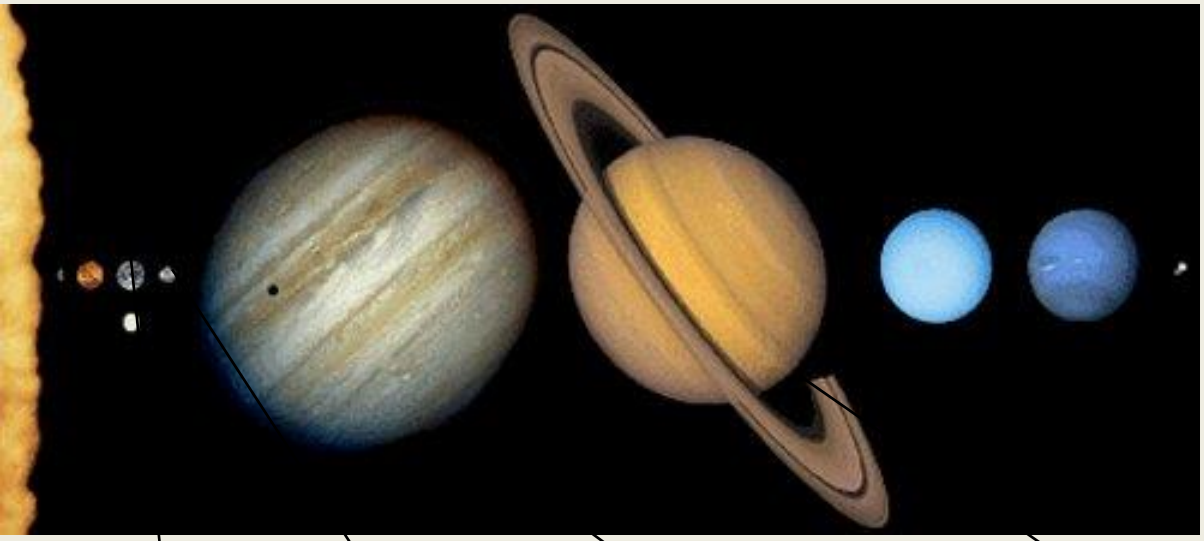
Resists dryness and desiccation

Tolerate pressure of 4000 m under sea level and 6000 m at high ranges.

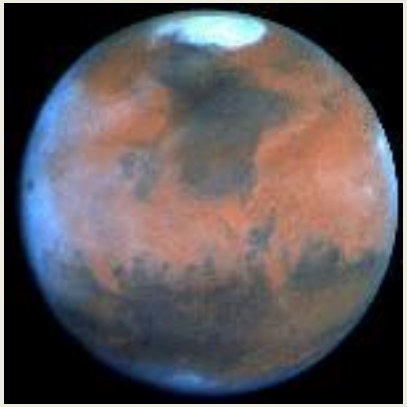
Enters into unhydrobiosis (dormancy for a long period)

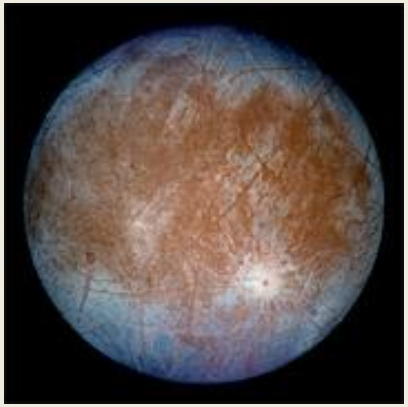
Tolerate high irradion doses

May stay in anaerobic condition.











EARTH **MARS** **EUROPA** **TITAN, ENCELADUS**

CONDITIONS ON MARS

1) DRY
2) COLD
3) UV RADIATION
4) LIQUID WATER
5) CO_2 and METHANE [CH_4]

LIFE ON MARS? PAST AND PRESENCE ON SUBSURFACE??

ANCIENT LIFE ON MARS ?

EVIDENCE FROM NASA IMAGES OF THE RED PLANET

CONTOURS OF RIVERS, CANYONS, CRATERS, FLOWING AND RUNNING WATER.

Groundwater May Have Played Important Role in Shaping Mars



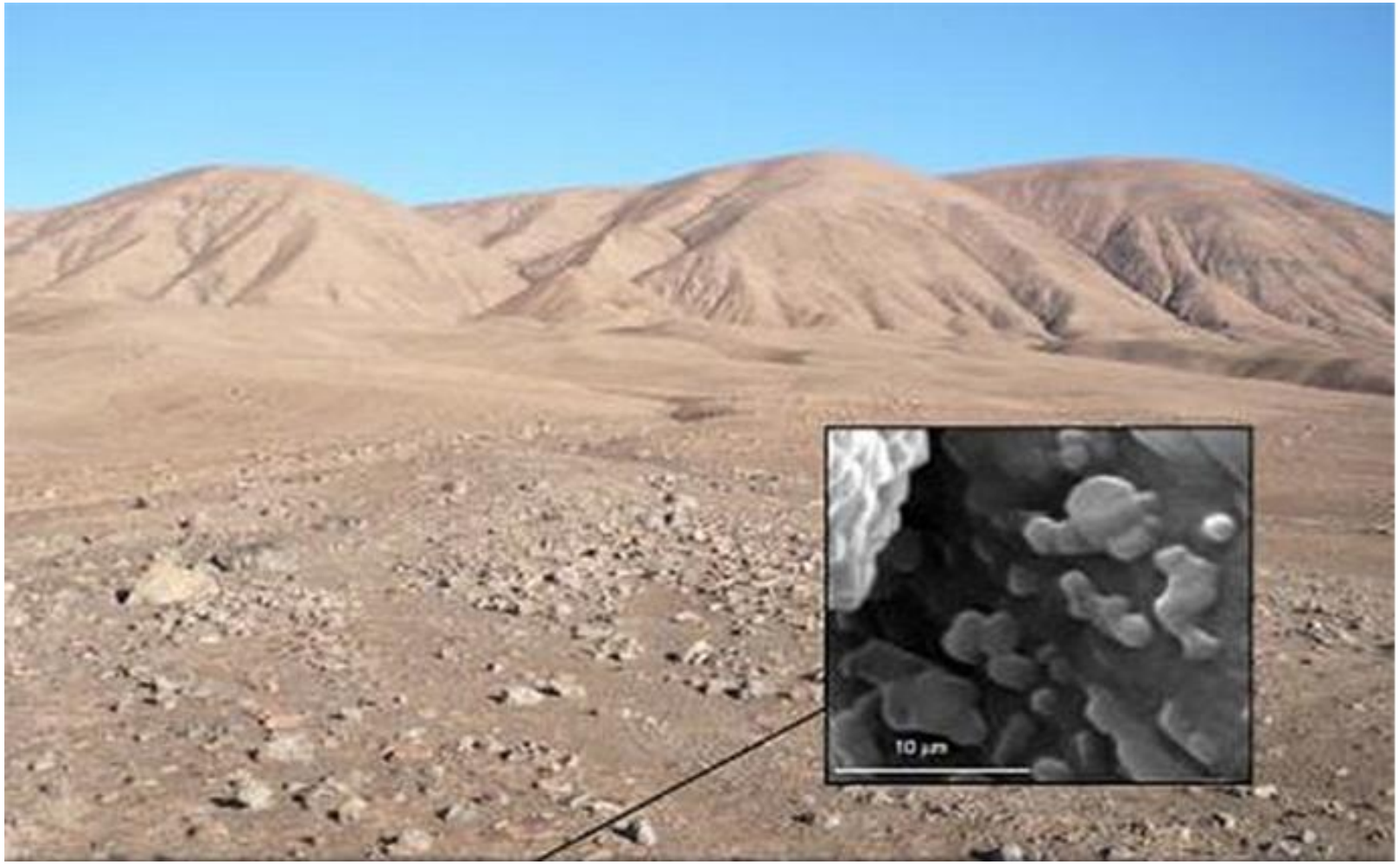
STAIRWAYS ON MARS



THE ATACAMA DESERT IN CHILI (L) SHARES FEATURES WITH SURFACE OF MARS (R)



Under Atacama desert is life



From EXTREMOPHILE to EXTRA-TERRESTRIAL LIFE

THE CHALLENGES

1) **DRY CONDITIONS;**
2) **TEMPERATURE EFFECTS**

(HYPER-THERMOPHILES vs. PSYCHROPHILES) PRESENT IN VARIOUS PLACES, (ANTARCTICA, SIBERIA, AND PERMAFROST)

EXTREMOPHILES ~ EXTRATERRESTRIL LIFE

- **COMPARING EXTREME HABITATS on EARTH with other PLANETS and some SATELLITES [MARS, Europa, Titan, Enceladus, Venus]**

- THE EXTREMOPHILES as ANALOGUES for LIFE FORMS in CELESTRIAL WORLDS

SUBSURFACE LIQ. WATER LAKES SIMILAR TO VOSTOK

AT THE SUB-ICY DEAPH OF MARS AND SATELLITES [AS EUROPA & ENCELADUS] ARE LIQUID WATER LAKES WARMED UP BY THERMO-VOLCANIC SOURCES. LIFE?

Discove

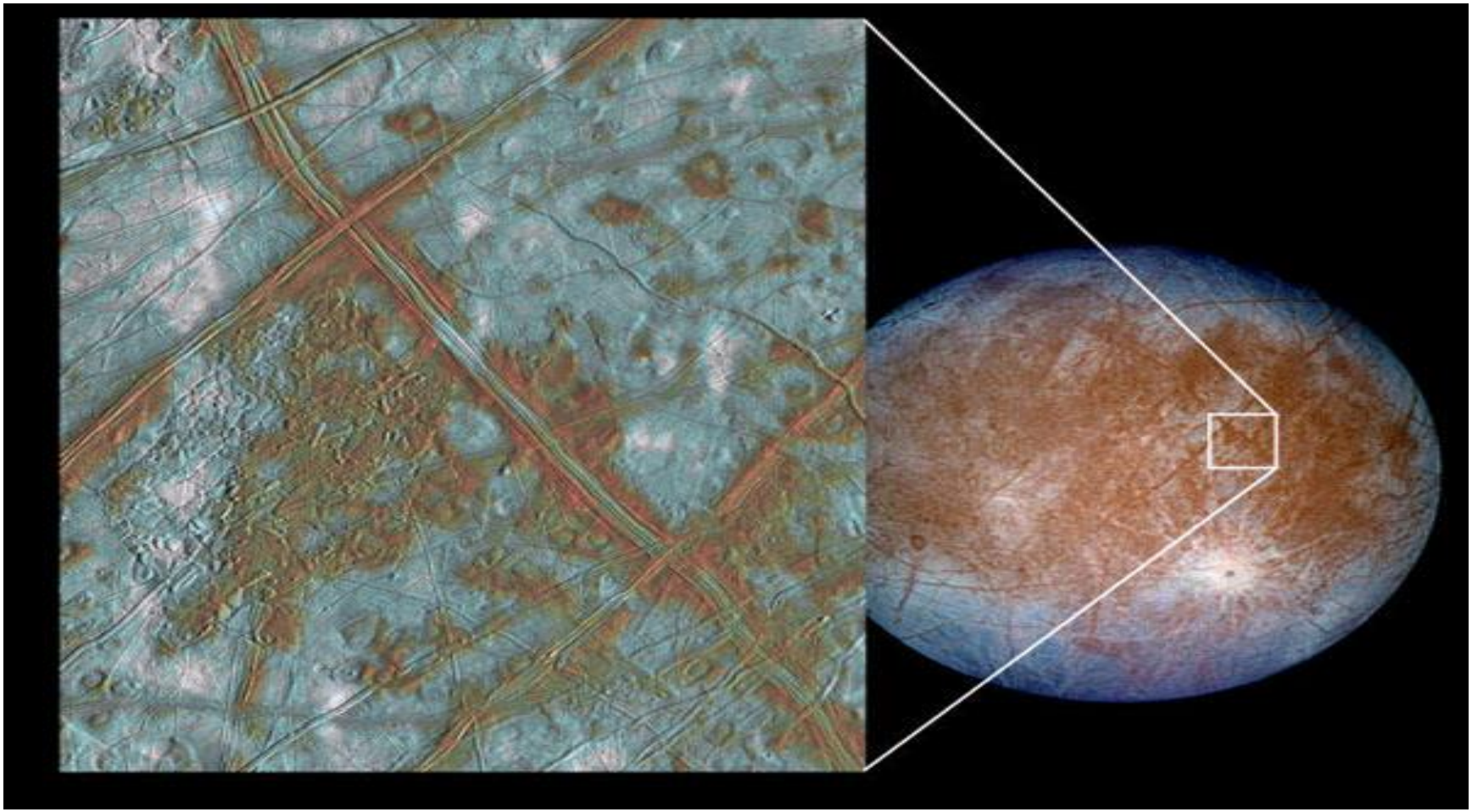
MAY 2002

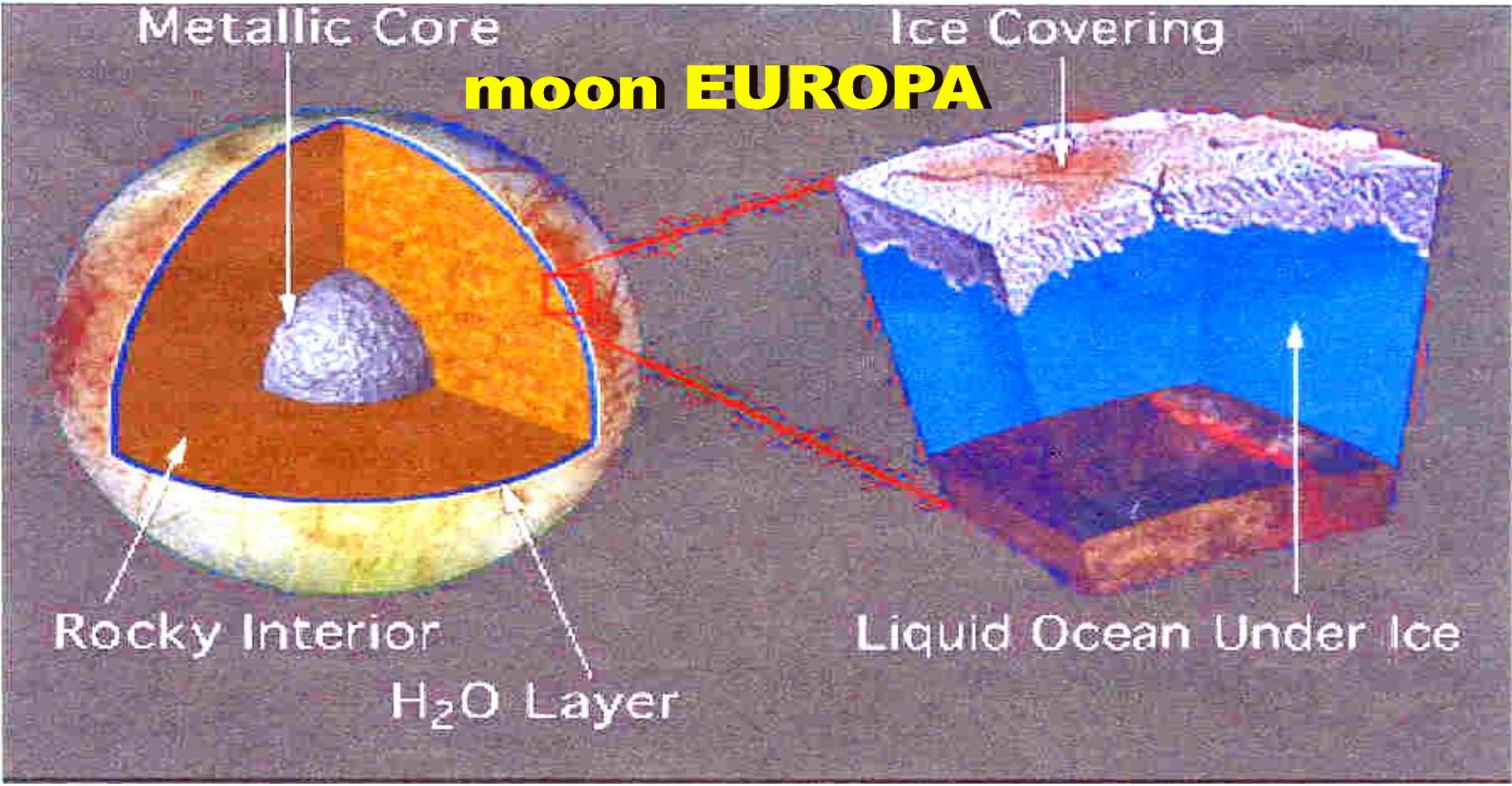


Is There Life on Europa?

Europa, about the size of E
moon, orbits 375,000 miles
gaseous Jupiter's cloud

Surface of **Europa** with moving lines





artist's drawings depict a proposed model of the subsurface structure of the Jovian

more than 100 kilometers. (Courtesy of NASA.)

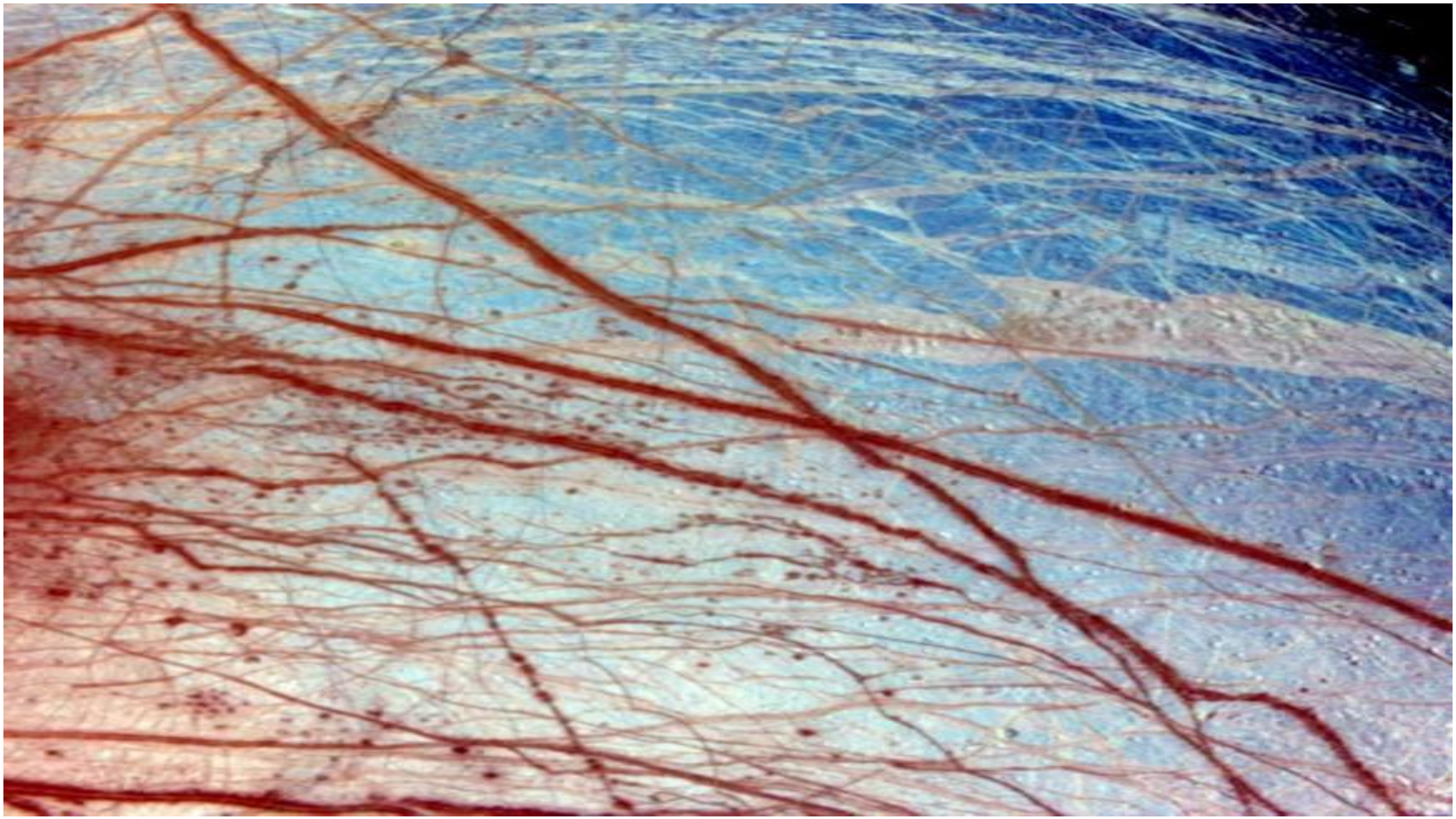
How Could We Detect Life in Europa's Geysers?



Artist's concept of a water vapor plume on Europa. (NASA/ESA/K. Retherford/SWRI)


THANK for
your ATTENTION

EUROP0A SURFACE



New Findings Say Mars Methane Comes from Life or Water — or Both

METHANE could be generated by either

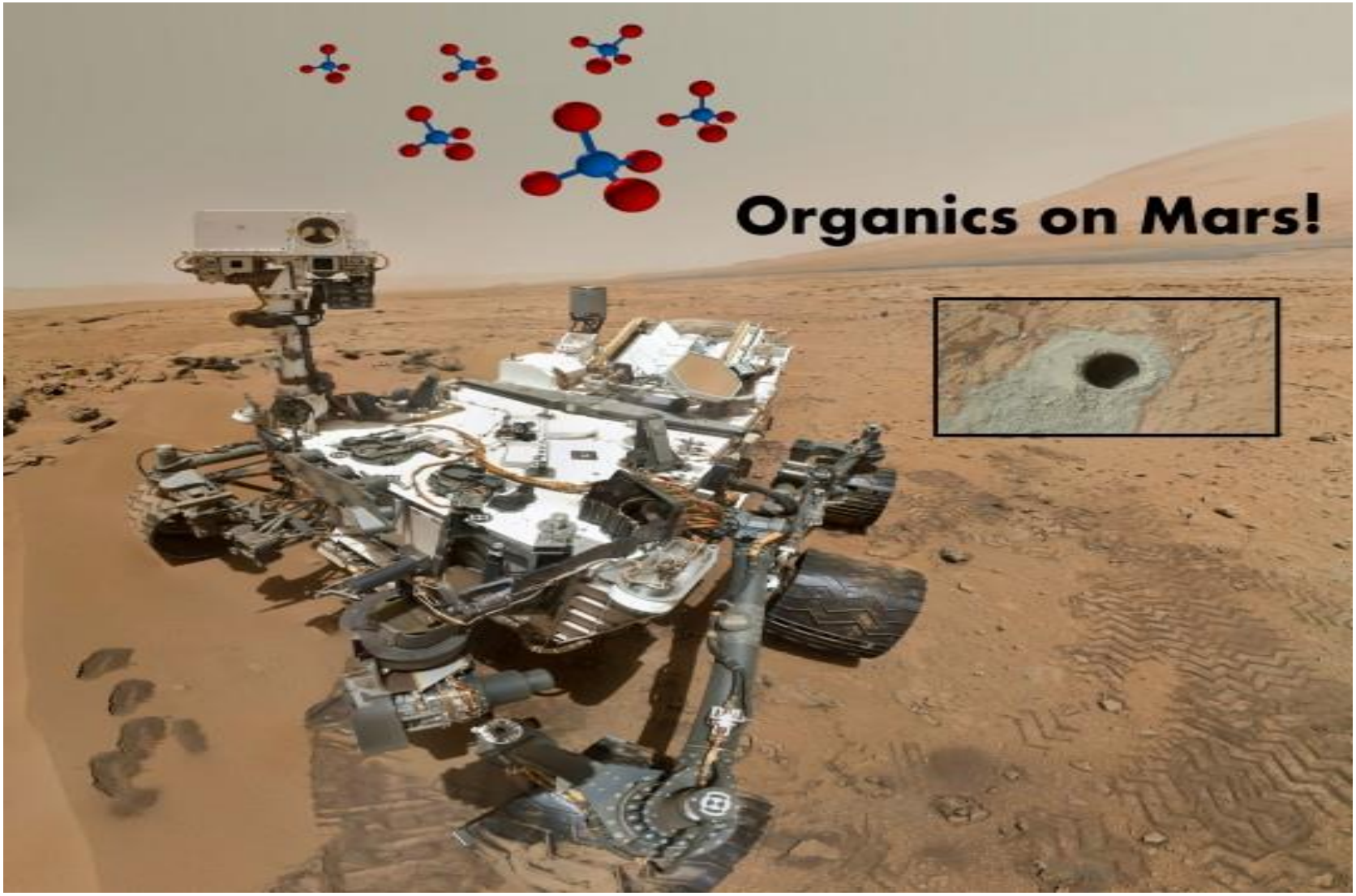
- LIFE or WATER, or maybe even BOTH.
- MICROORGANISMS living in the Martian
- soil could be producing methane gas as a
- by-product of their metabolic processes, or
- methane might be created as a result of
- reactions between volcanic rock and water.

- Either way, the prospect is exciting.

Methane on Mars?

NASA's Curiosity Rover detects Methane, Organics on Mars

June 19, 2016



VOSTOK LAKE

(ANTARCTICA)

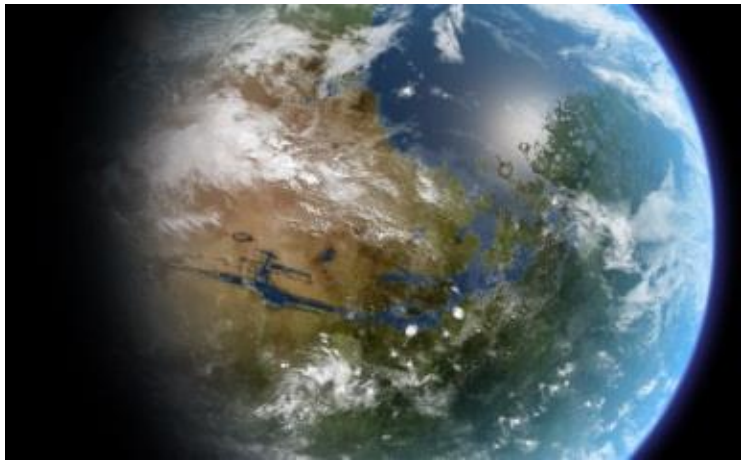
AT DEPTH OF 4 KM IS A LIQUID WATER LAKE.

DRILLINGS THROUGH ICY LAYERS [UP TO 3.8 KM] HAVE EXPOSED VARIOUS GENERA OF PROKARYOTES & EUKARYOTIC MICROORGANISMS .


STROMATOLITES

How Do We Terraform Mars?

June 26, 2016



*As part of our continuing "Definitive Guide To **Terraforming**" series, Universe Today is happy to present our **guide to terraforming Mars.***

*At present, there are several plans to put astronauts and ever settlers on the Red Planet. But if we really want to live there someday, we're going **to need to do a complete planetary renovation**.*

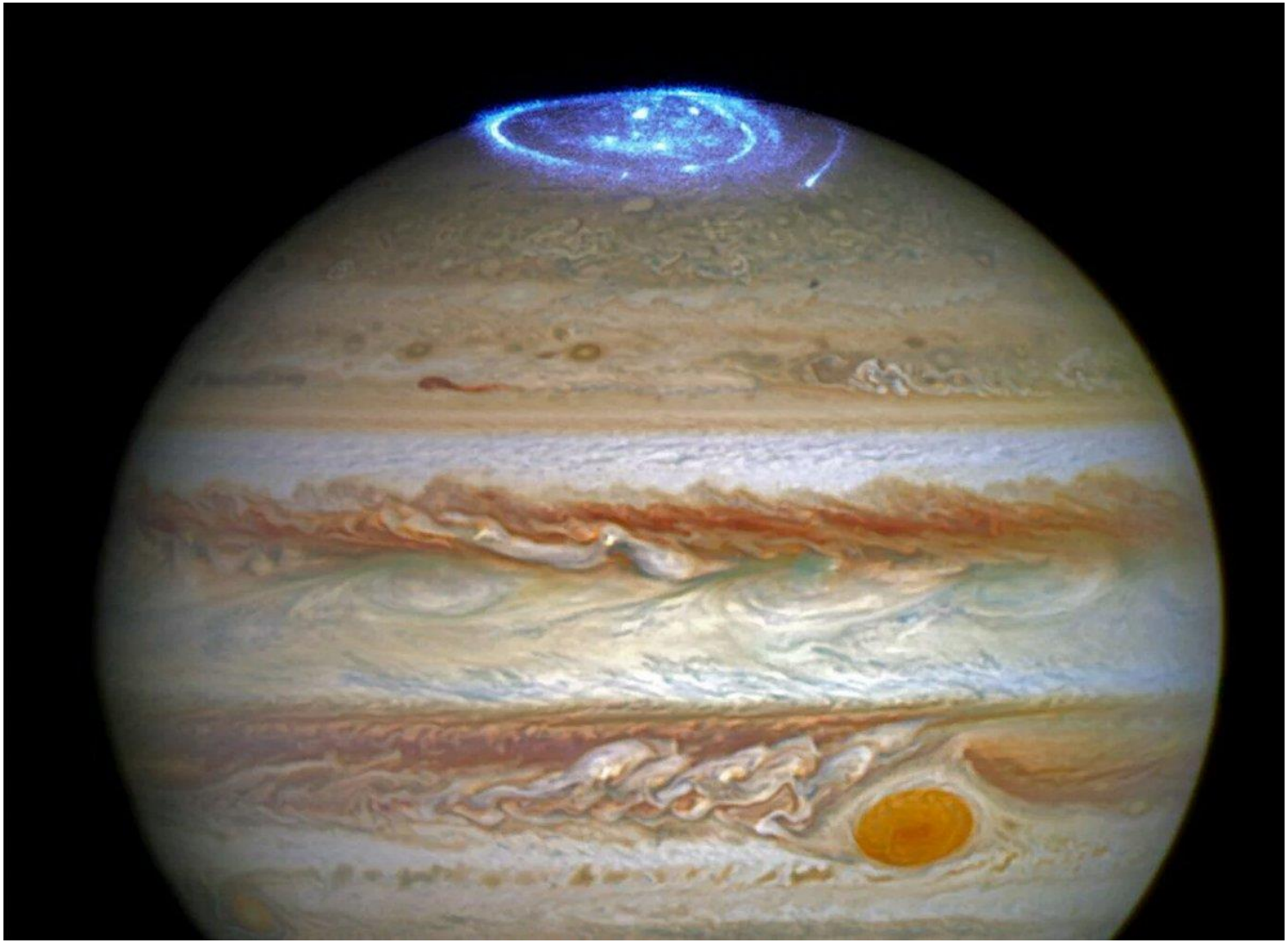
Nature 457, 384-385 (22 January 2009)

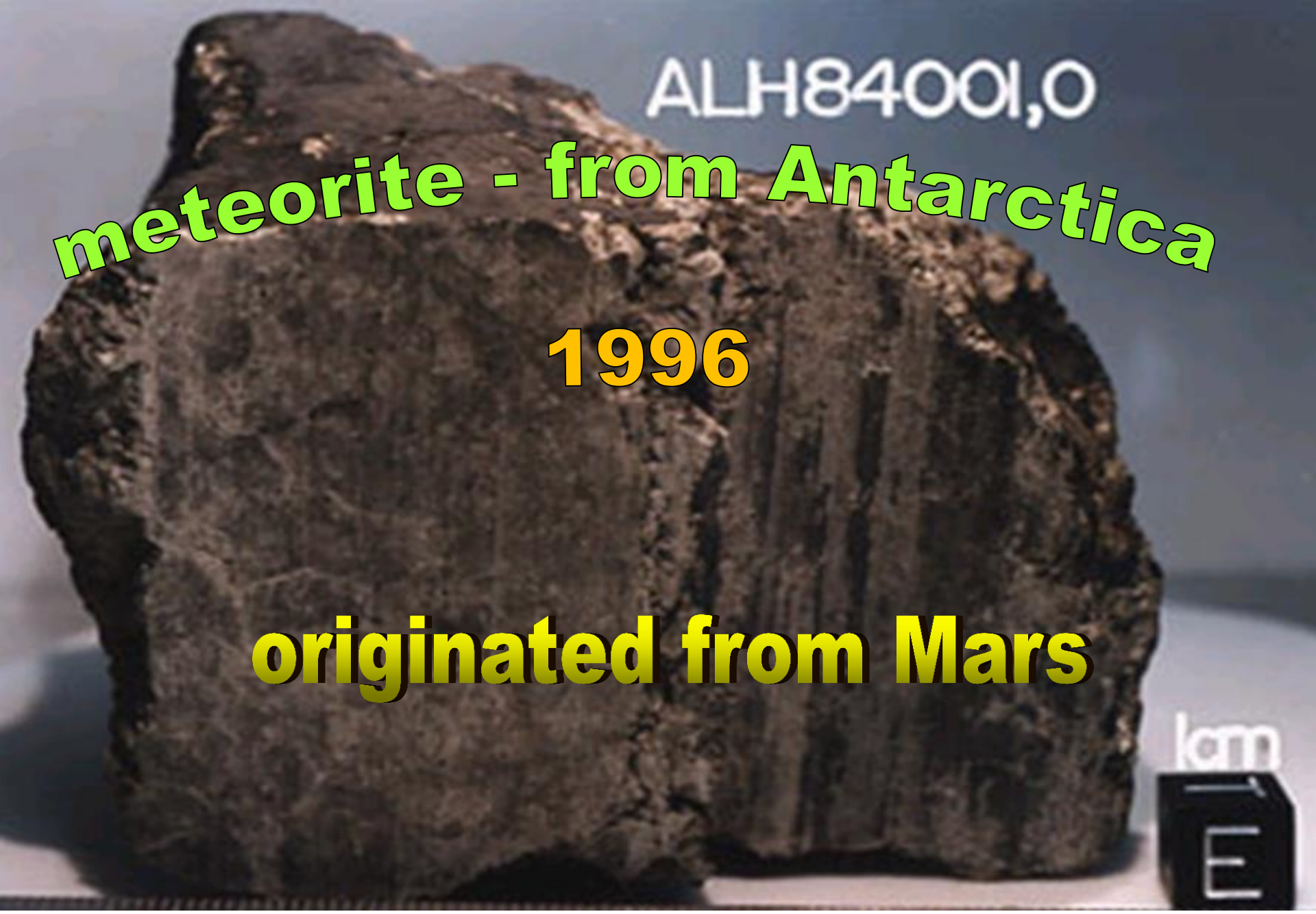
Is there life on Europa?

Europa: The Search for Life on Jupiter's Ocean Moon

by Richard Greenberg

Aurora Jupiter North Pole (Hable Telescope)




ALH84001,0
meteorite - from Antarctica
1996
originated from Mars

Tardigrades Multisegmented Extremophilic microbes











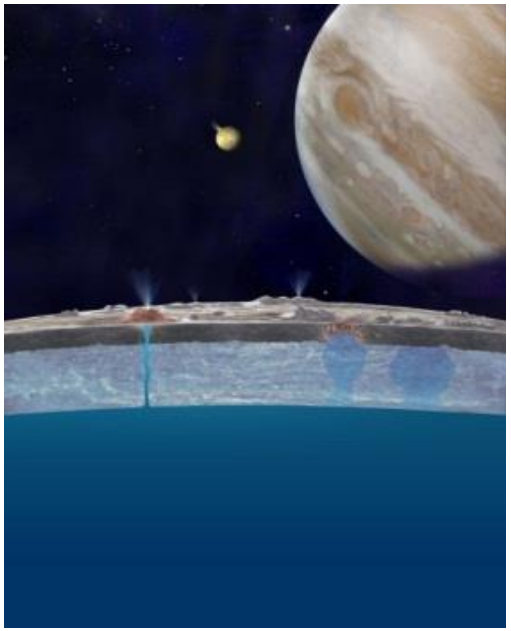
EUROPA OCEAN WORLD

Icy Hot: Europa's Frozen Crust Could Be Warmer Under its Surface [sub-icy layer]

Icy Worlds Might Be Alive on the Inside

Many small, frozen worlds seem to have warm underground oceans, making the search for alien life more exciting — and more confusing.

By Corey S. Powell
RELATED TAGS: EXTRATERRESTRIAL LIFE



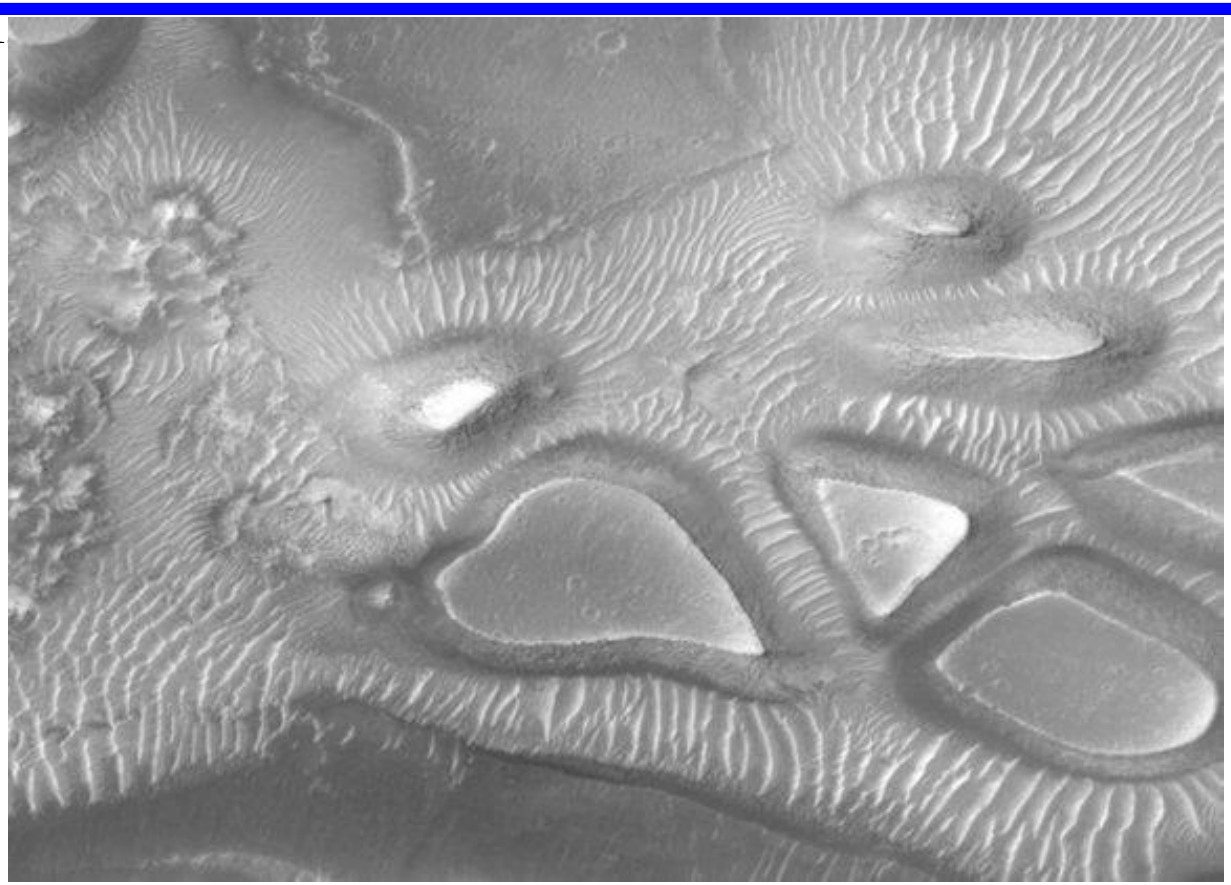
The global ocean on Jupiter's moon **Europa contains about twice the liquid water of all the Earth's oceans combined.** There may be plenty of **oxygen available in that ocean to support life, a hundred times more oxygen than previously estimated.**

CONCLUSIONS

1) **If Earth microbes can thrive in extreme environments, could it not be that in the future similar microorganisms might also be observe in the above mentioned celestial bodies?**
2) Furthermore, if bacteria are known to survive for **millions of years below glaciers** in Antarctica, and in other places on Earth, why would they not thrive underneath **the ice caps of Mars, and on the Europan Oceans?**
3) All the above facts serve to encourage us to intensify our search for biomarkers on the nearby planets and on some of their satellites.

With Love from Universe Today

February 15, 201



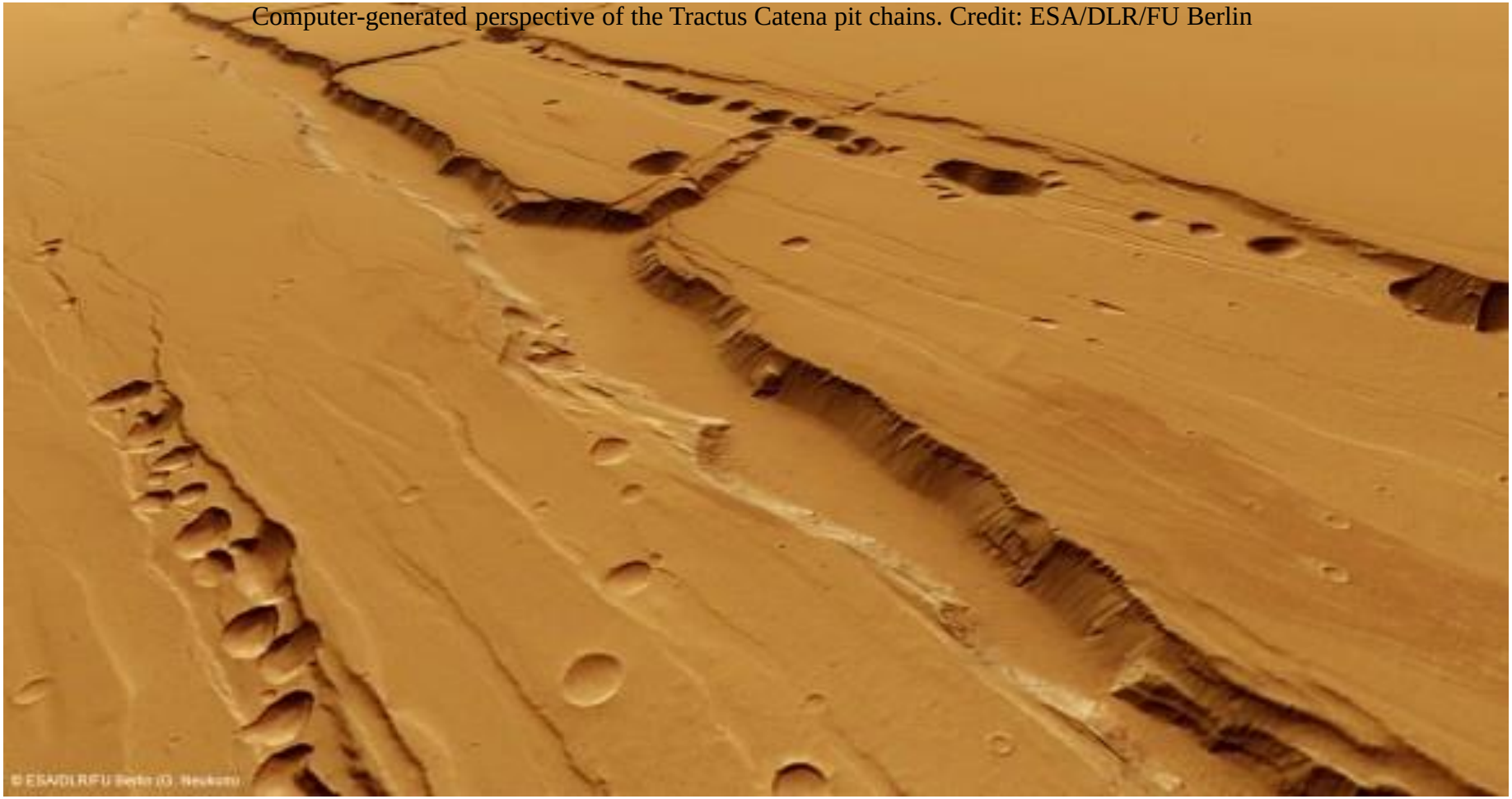
This image from the Mars Global Surveyor shows a heart-shaped crate amid other 'box of chocolates' shapes. Credit: Malin Space Science Systems

Extremophiles under us in land

CRITTERS DEEP BENEATH EARTH'S SURFACE has set the world of microbiology on its head while exciting astrobiologists about the pof LIFE ON OTHER PLANETS. A community of

BACTERIA WAS FOUND 2.8 KILOMETERS BELOW GROUND IN A GOLDMINE SUBSISTS WITHOUT SUNLIGHT OR OXYGEN. The species Candidatus Desulforudis audaxviator is an amazing discovery, and or Organism that could survive below the surface of mars or saturn's sixth largest moon enceladus.

Could There Be Life In Them Thar Pits?



Computer-generated perspective of the Tractus Catena pit chains. Credit: ESA/DLR/FU Berlin

Storms and Lakes on Titan Revealed by Computer Modeling



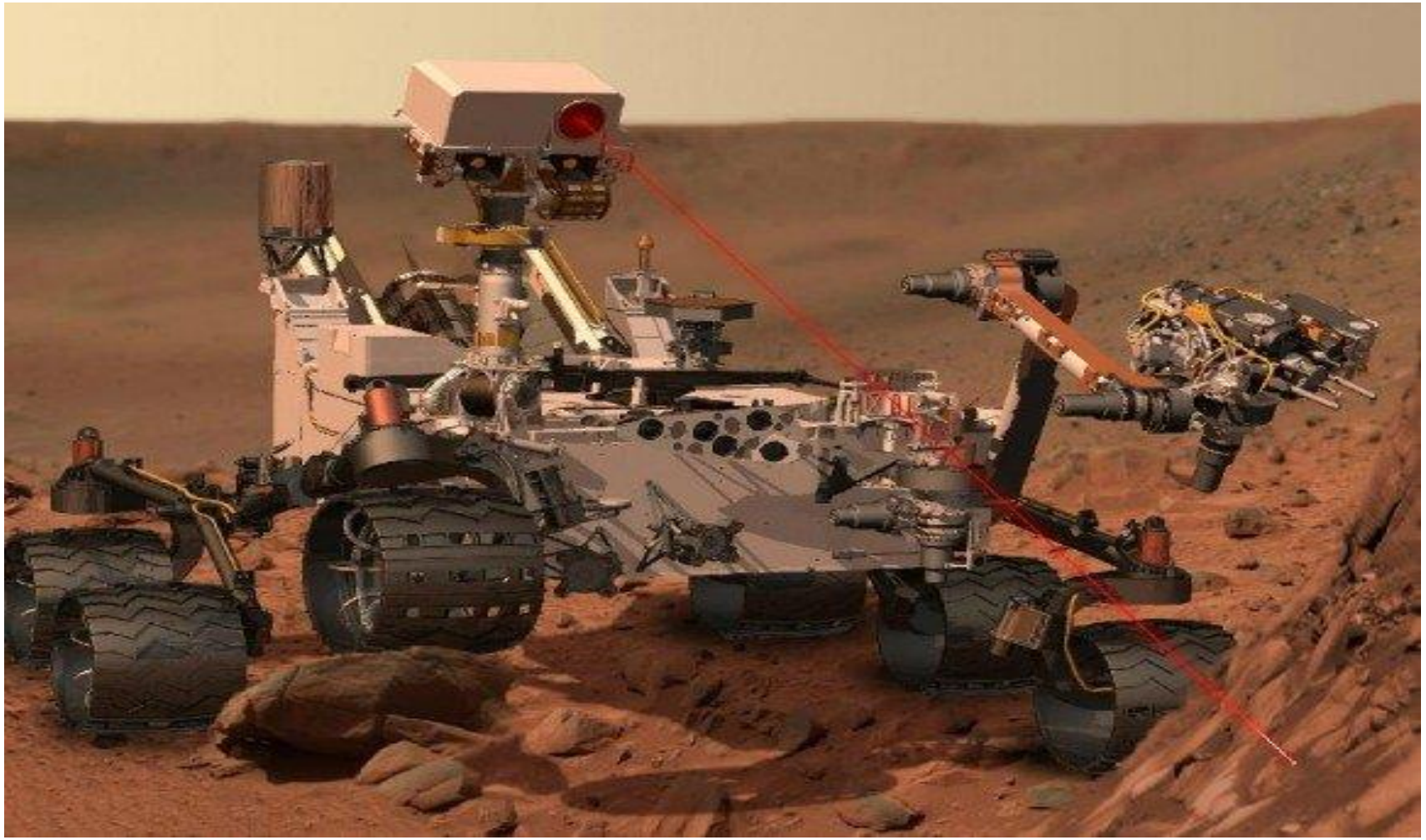
An artist's imagination of hydrocarbon pools, icy and rocky terrain on the surface of Saturn's largest moon Titan. Image credit: Steven Hobbs (Brisbane, Queensland, Australia).

BIG FOOT ON MARS



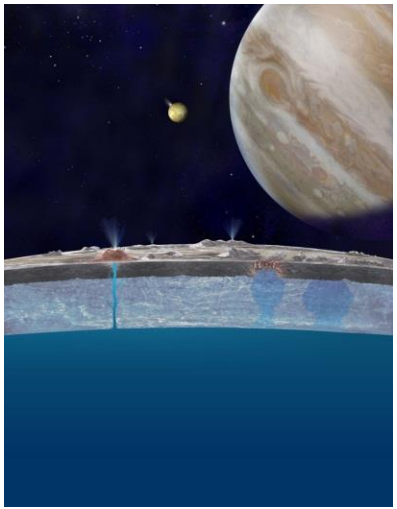
NASA's Curiosity Search for Signs [Ingredients] of Martian Life

work in Gale crater firing a laser on Mars



Icy Worlds Might Be Alive on the Inside

Many small, frozen worlds seem to have warm underground oceans, making the search for alien life more exciting — and more confusing.



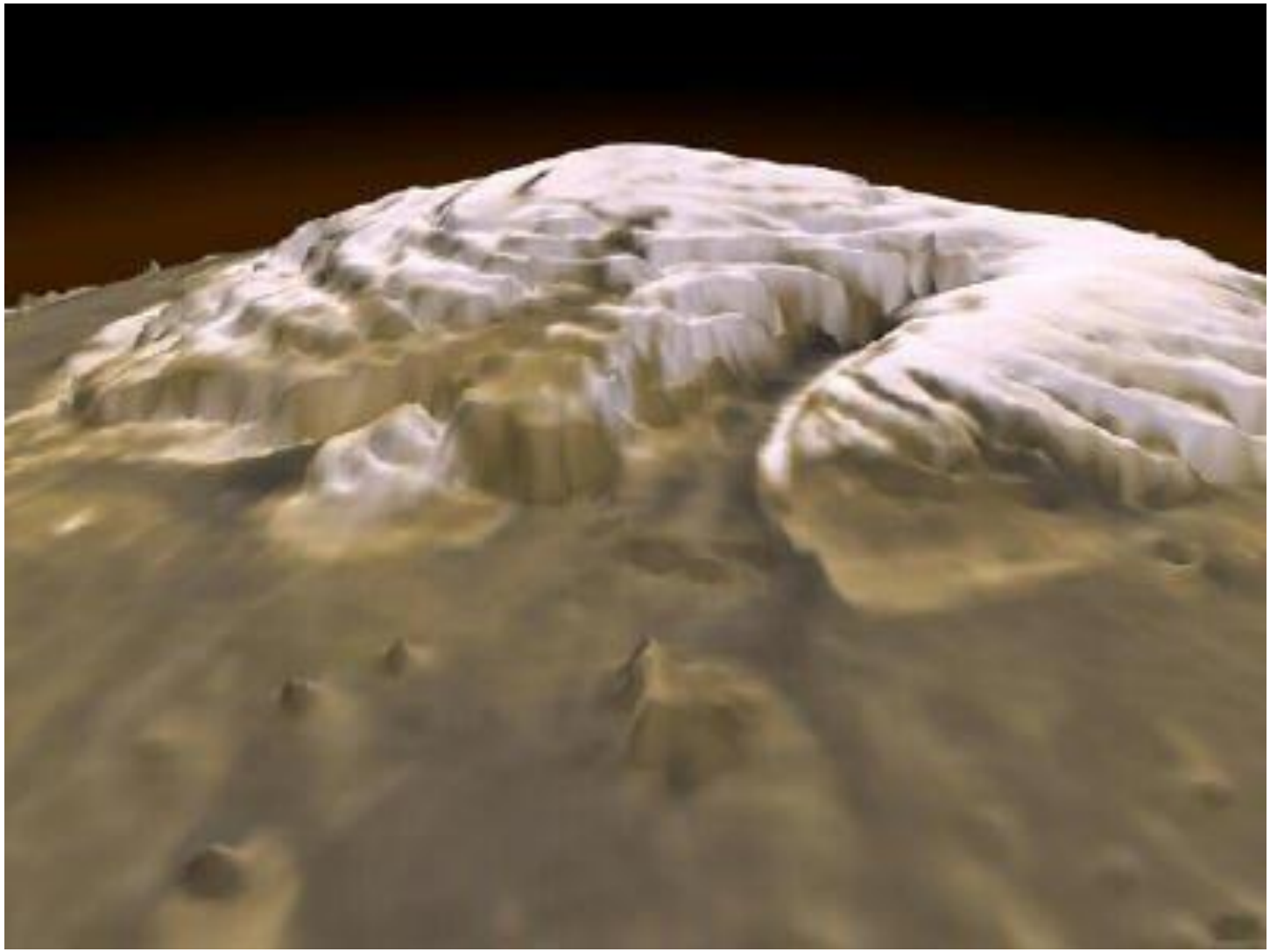
LANDSCAPE ON MARS



Europa Submarine Prototype

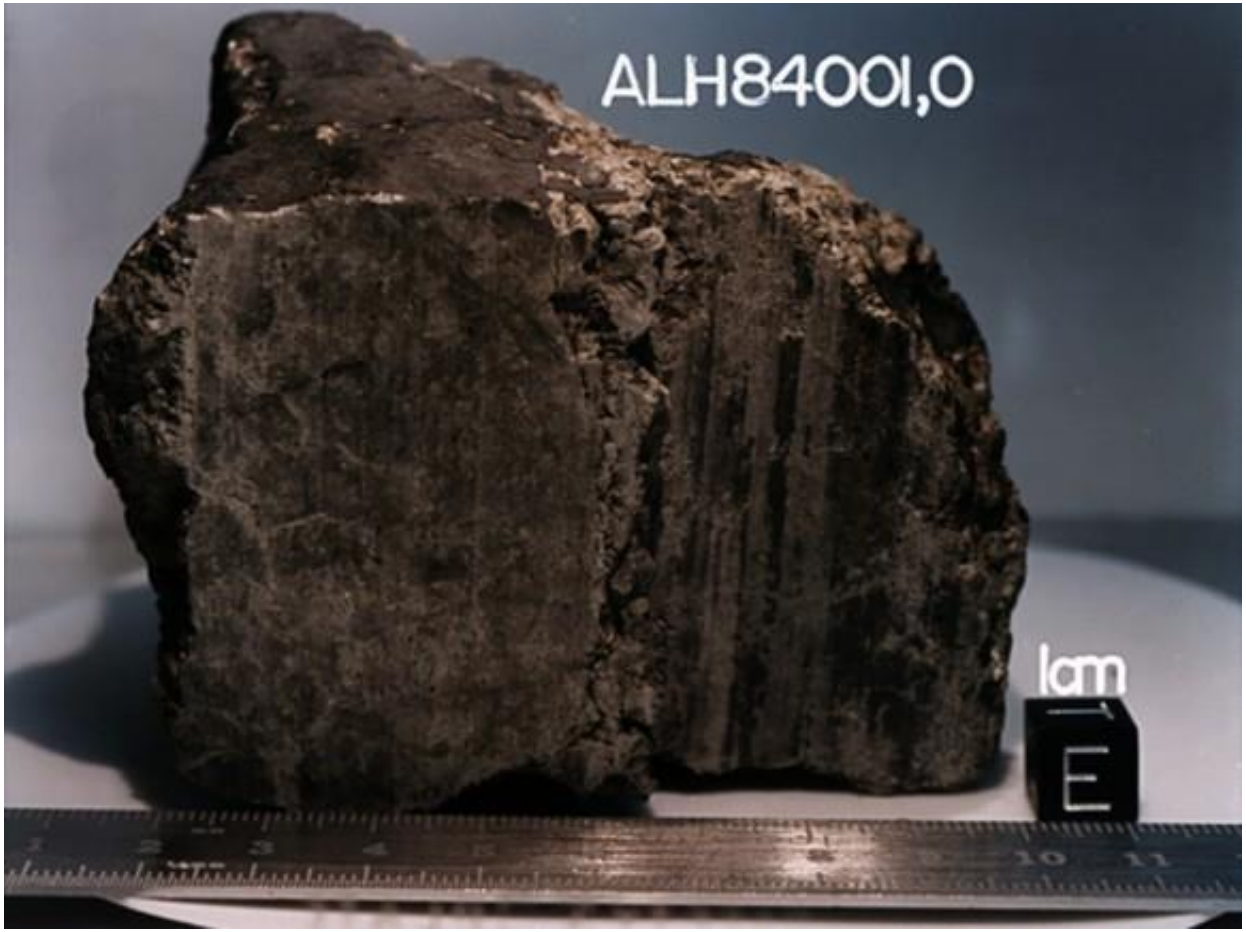


LOTS OF PURE WATER ICE AT MARS NORTH POLE



Univers Today – June 21, 2012

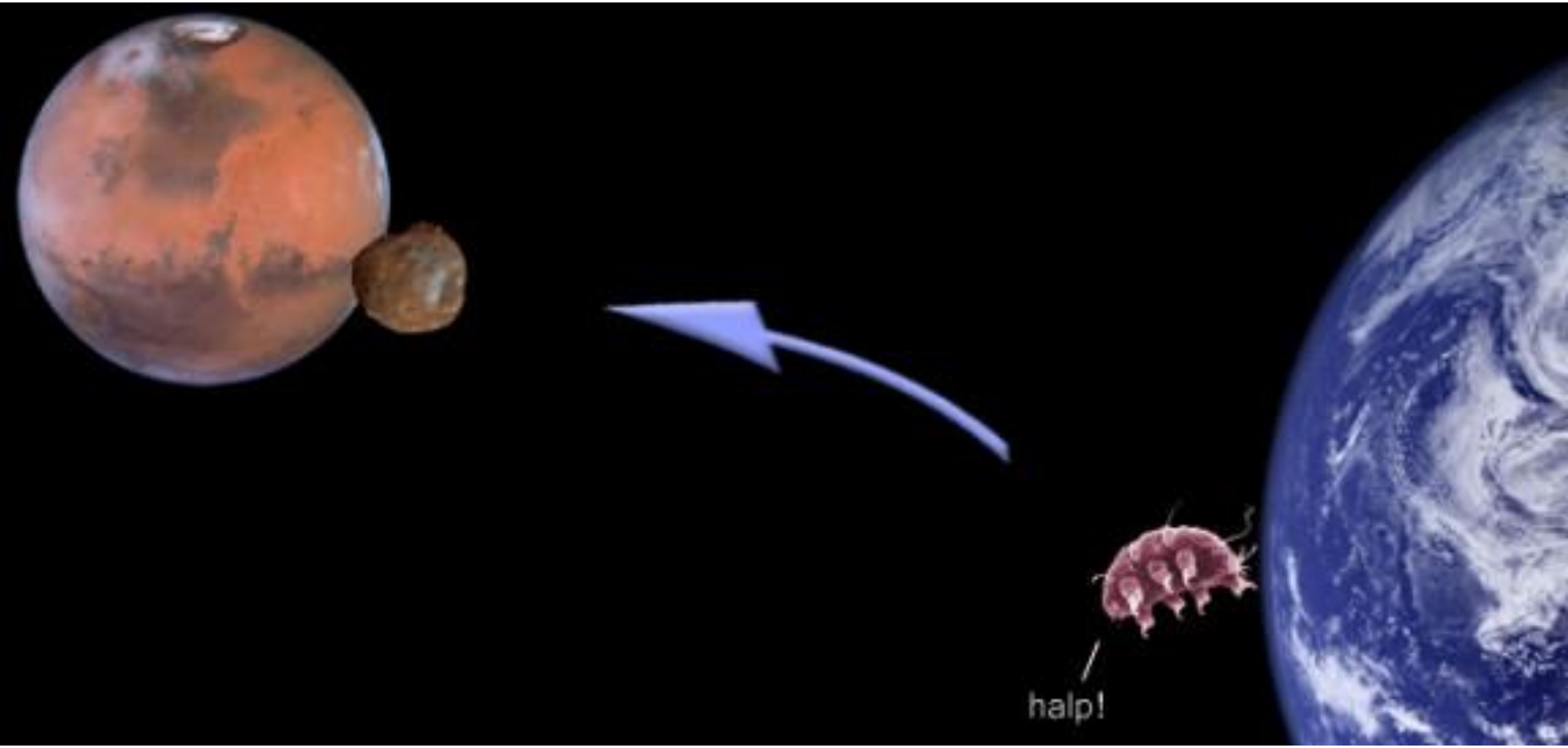
Organics Found in Mars Meteorites, But Nothing Biological



Microbes recently discovered 1.6 kilometres (1 mile) *below* the seabed off the coast of Canada. The living conditions are cramped, environment is a **searing 100°C** (212F), and yet **these hardy cells appear to be thriving**.

This new discovery of life so deep below the Earth's surface may set some new limits on just how extreme life can be on other planets...

Russian Space Agency send Terrestrial Life to Phobos (Martian Moon)



Bacteria Could Survive in Martian Soil [Oct. 31. 09] - Microsoft Word

Normal + Befor 100%

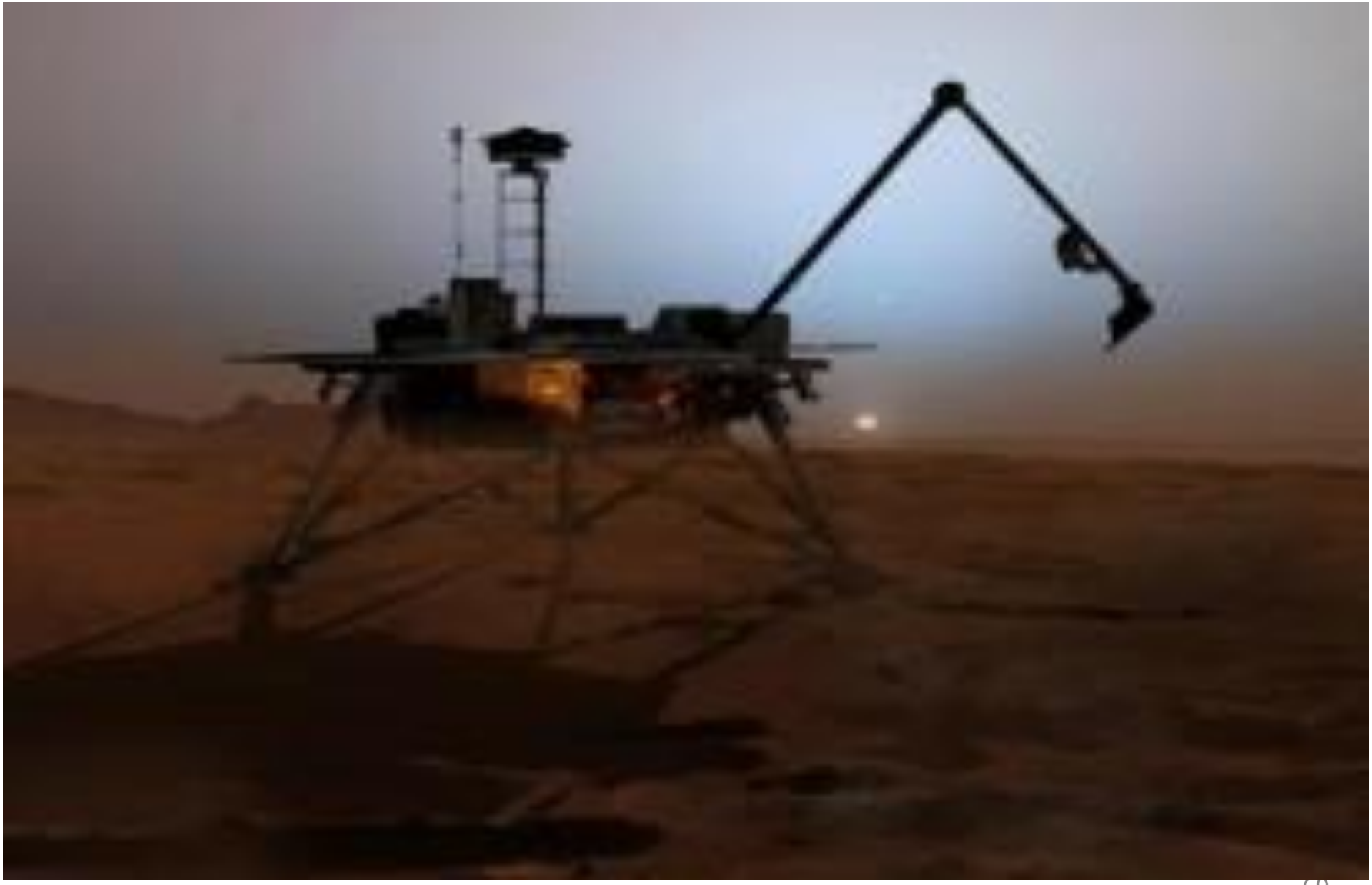
File Edit View Insert Format Tools Table Click to Convert Window Help Adobe PDF Acrobat Comments



Bacteria can survive on Mars

Multiple missions have been sent to Mars with the hopes of testing the surface of the planet for life—or the conditions that could create life—on the Red Planet. The question of whether life in the form of bacteria (or something even more exotic) exists on Mars is hotly debated and still requires a resolute yes or no

Imminent Discovery of Life On Mars?



ICE AND WATER ON MARS in a North Pole crater.



Salt Pilars in the Dead Sea



Russia delays Lake Vostok drill (press)

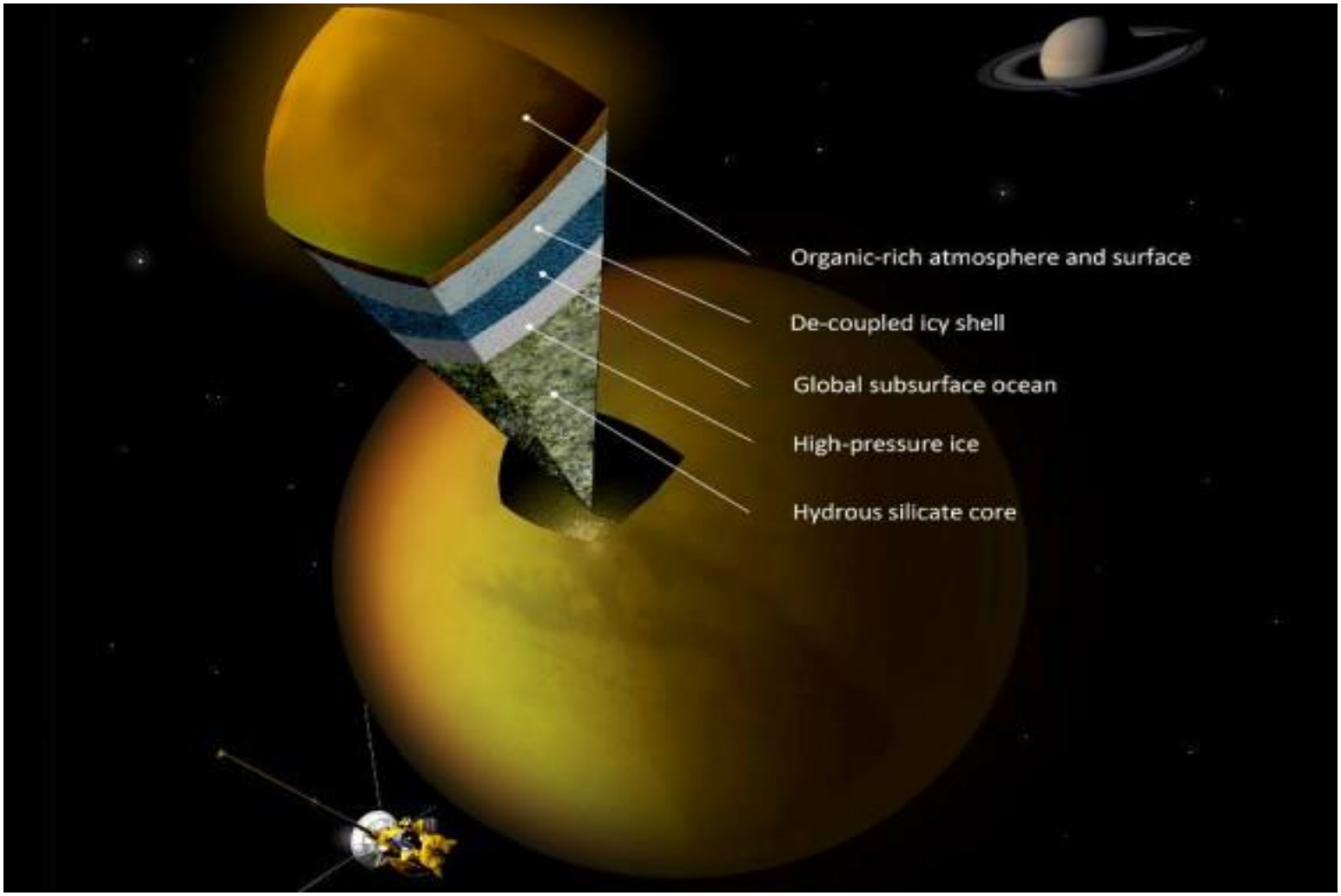
- Antarctica's hidden water will keep its secrets for another year.
- Lake Vostok lies thousands of metres below Vostok Station, the coldest recorded place on Earth.

Archaean Halophiles

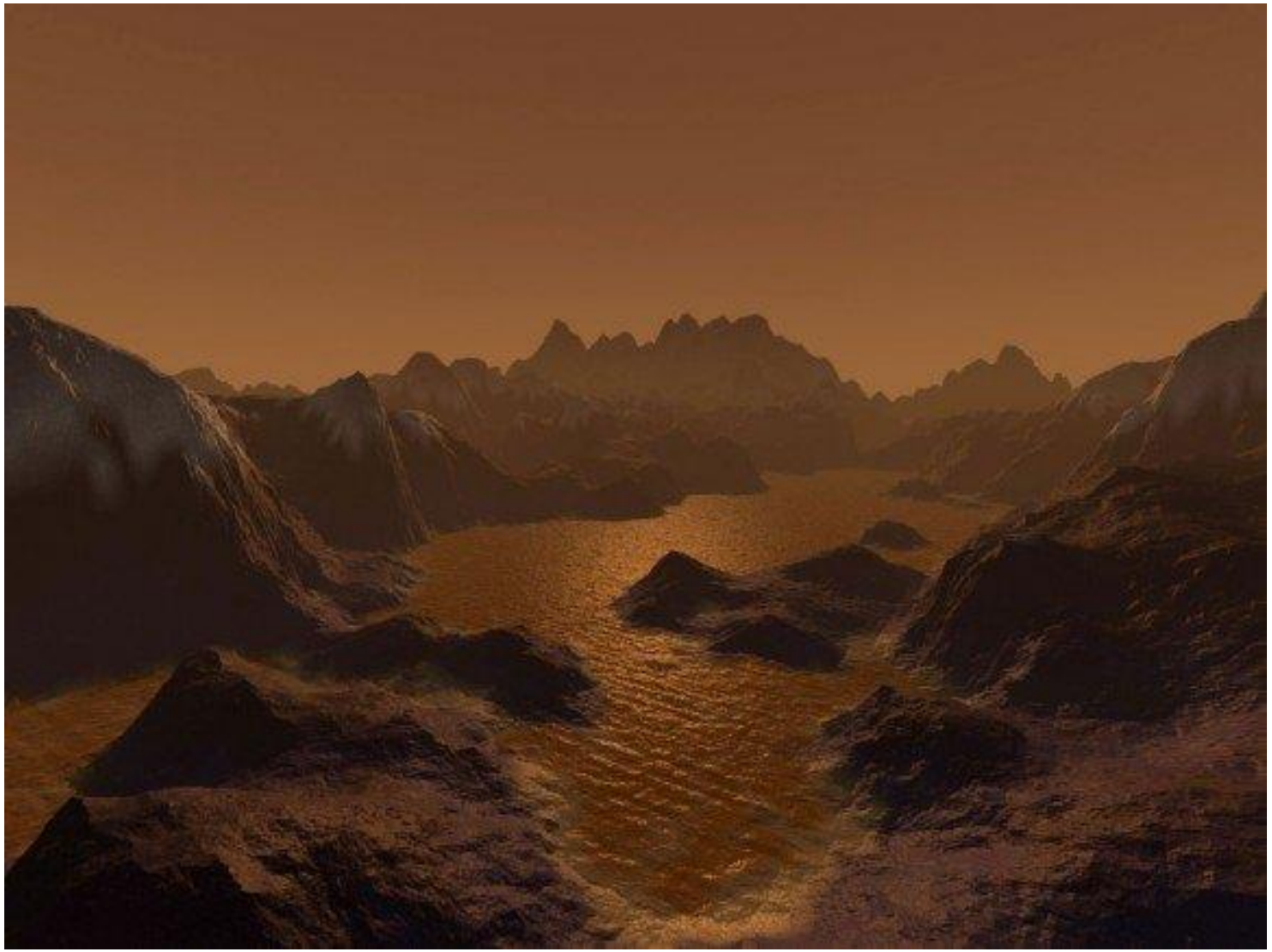


Halorhodopsin

TITAN TIDES SUGGESTS A SUBSURFACE OCEAN



Storms And Lakes On Titan Revealed By Computer Modeling



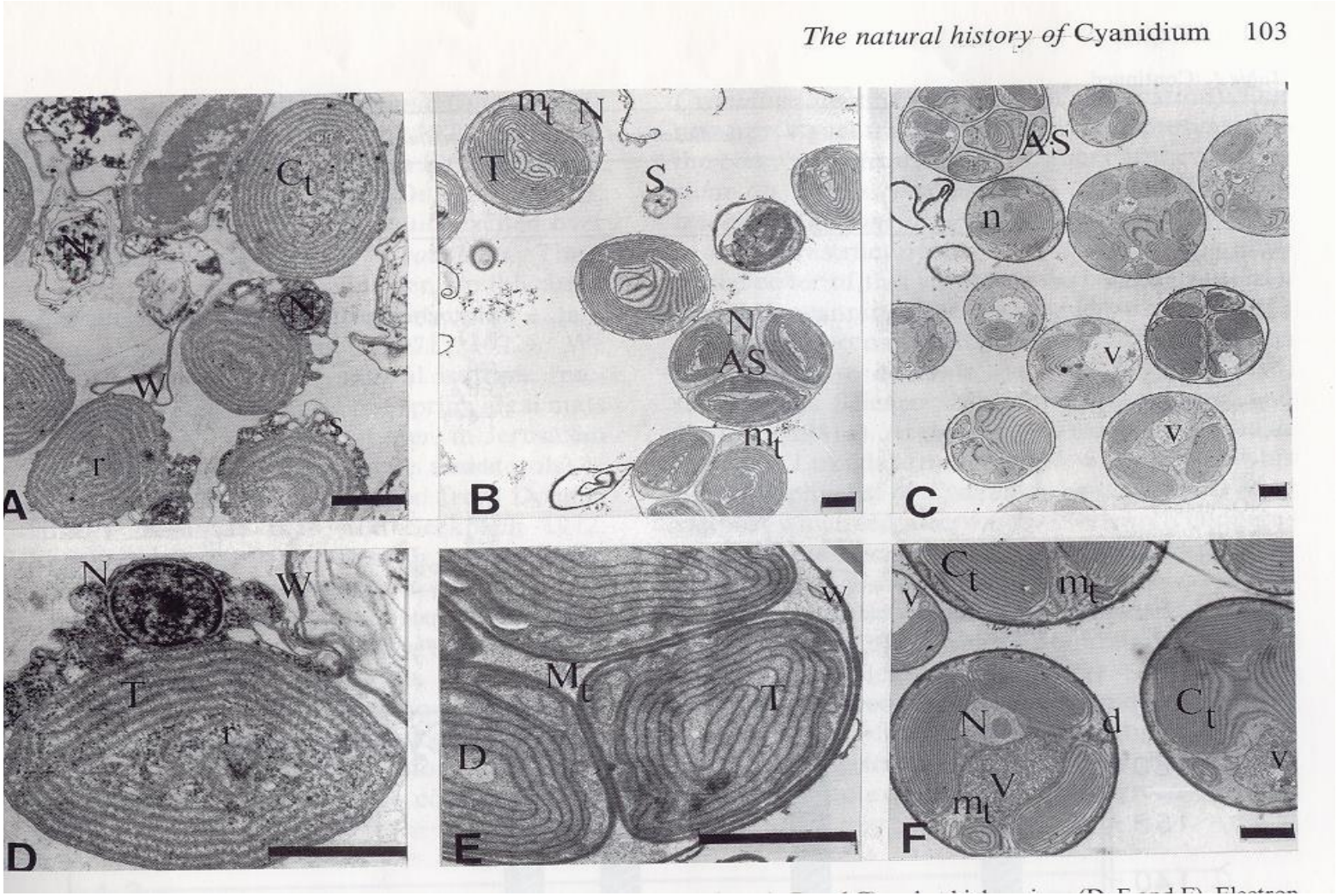
CONCLSIONS

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3) All the above facts serve to encourage us to intensify our search for biomarkers on the nearby planets and on some of their satellites.

Three genera of the Cyanidia

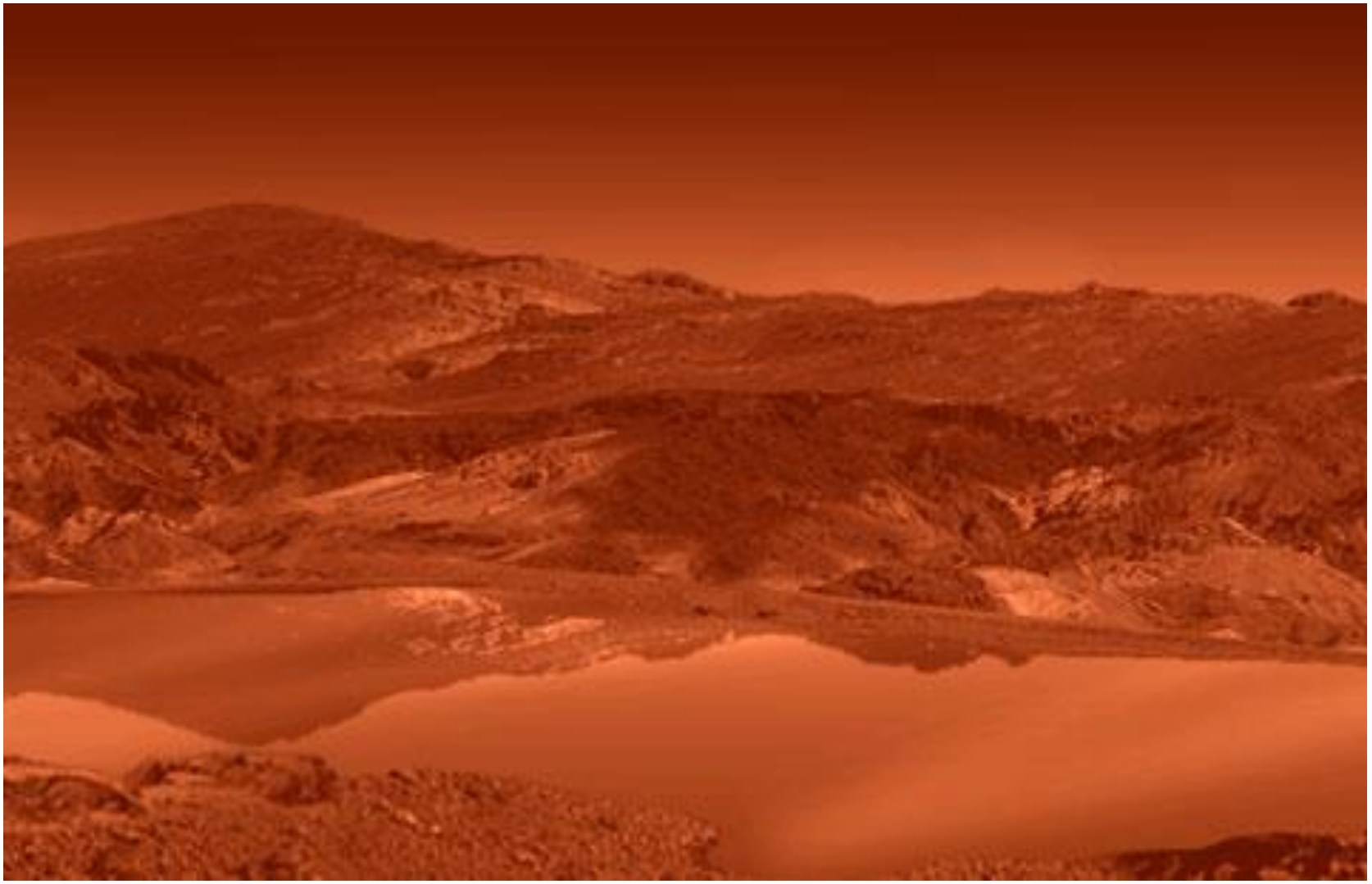


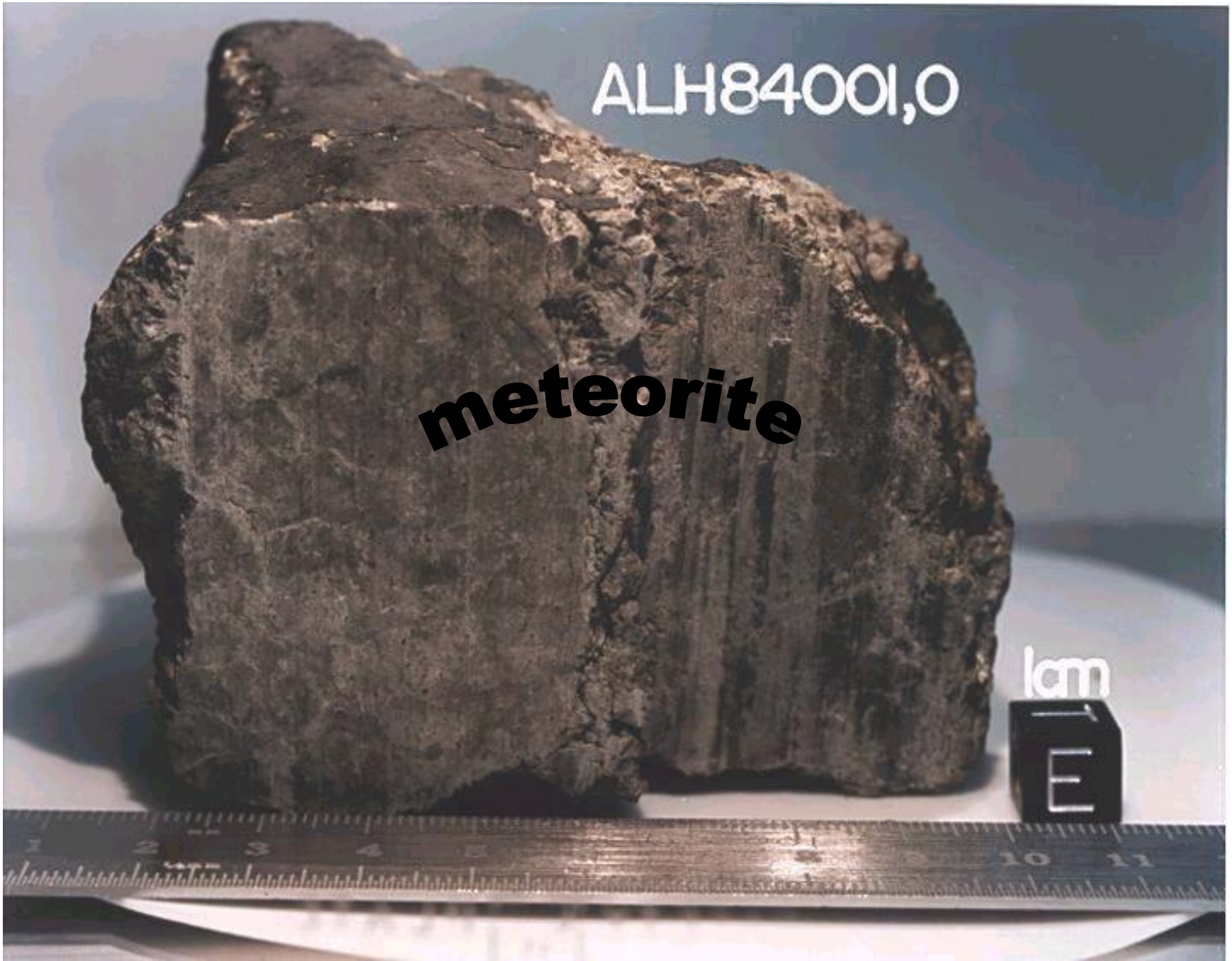
Dunaliella salina



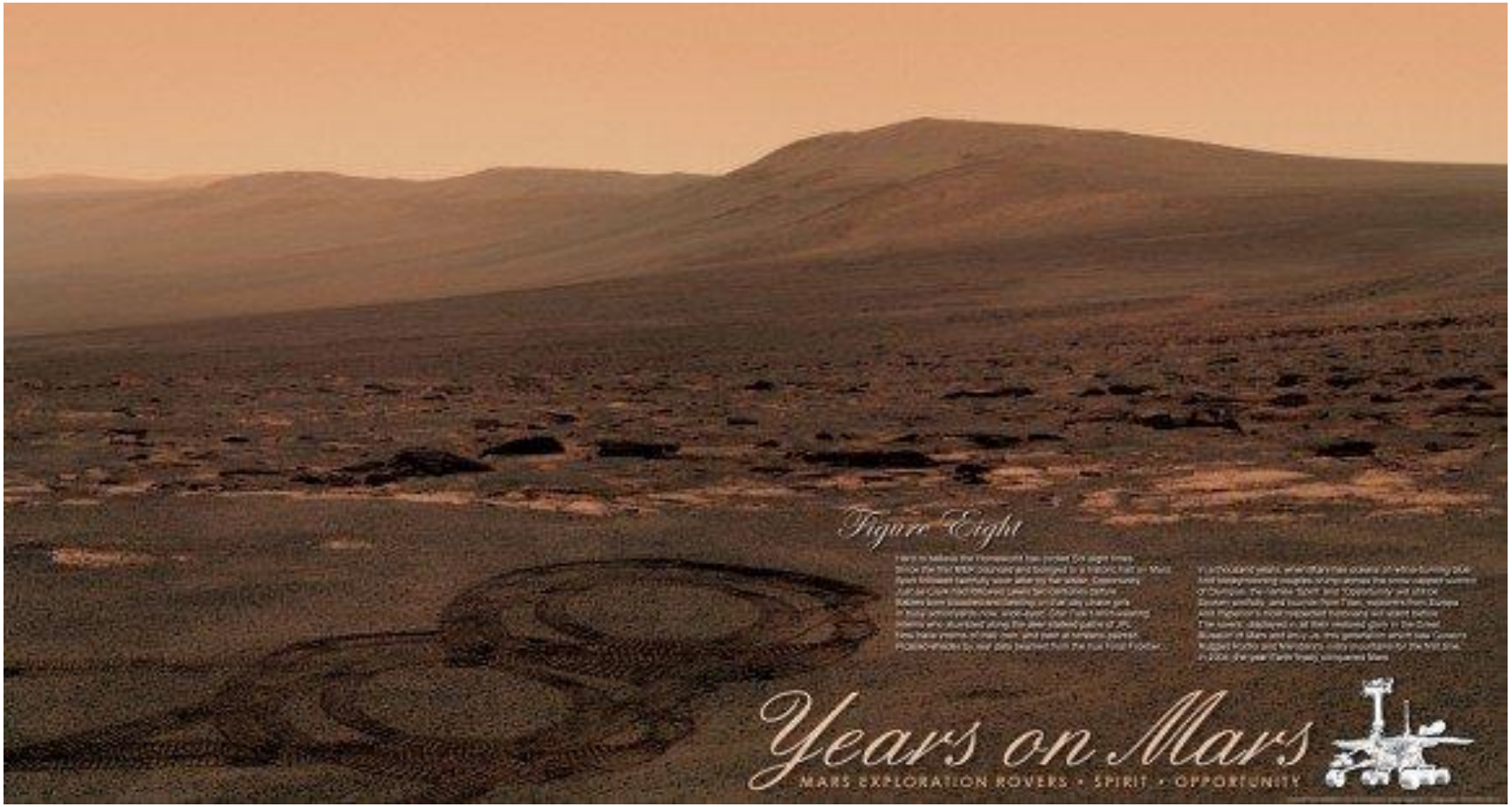
Green algae around salt x'tals

Titan (satellite of Saturn) organic seas




ALH84001,0
meteorite
1cm

8 YEARS ROVER ON MARS



Ancient Domes Reveal 3.45-billion-year-old Life History

Rare, paleo-surface view of how conical stromato lites would appear if one SNORKELED IN THE SHALLOWS OF A REEF. Ancient, dome-like rock structures contain clues that life was active on Earth 3.45 billion years Ago, according to new research — and the findings could help shed light on life's history on Earth and other planets, including Mars.

•



Europa Capable of Supporting Life, Scientist Says

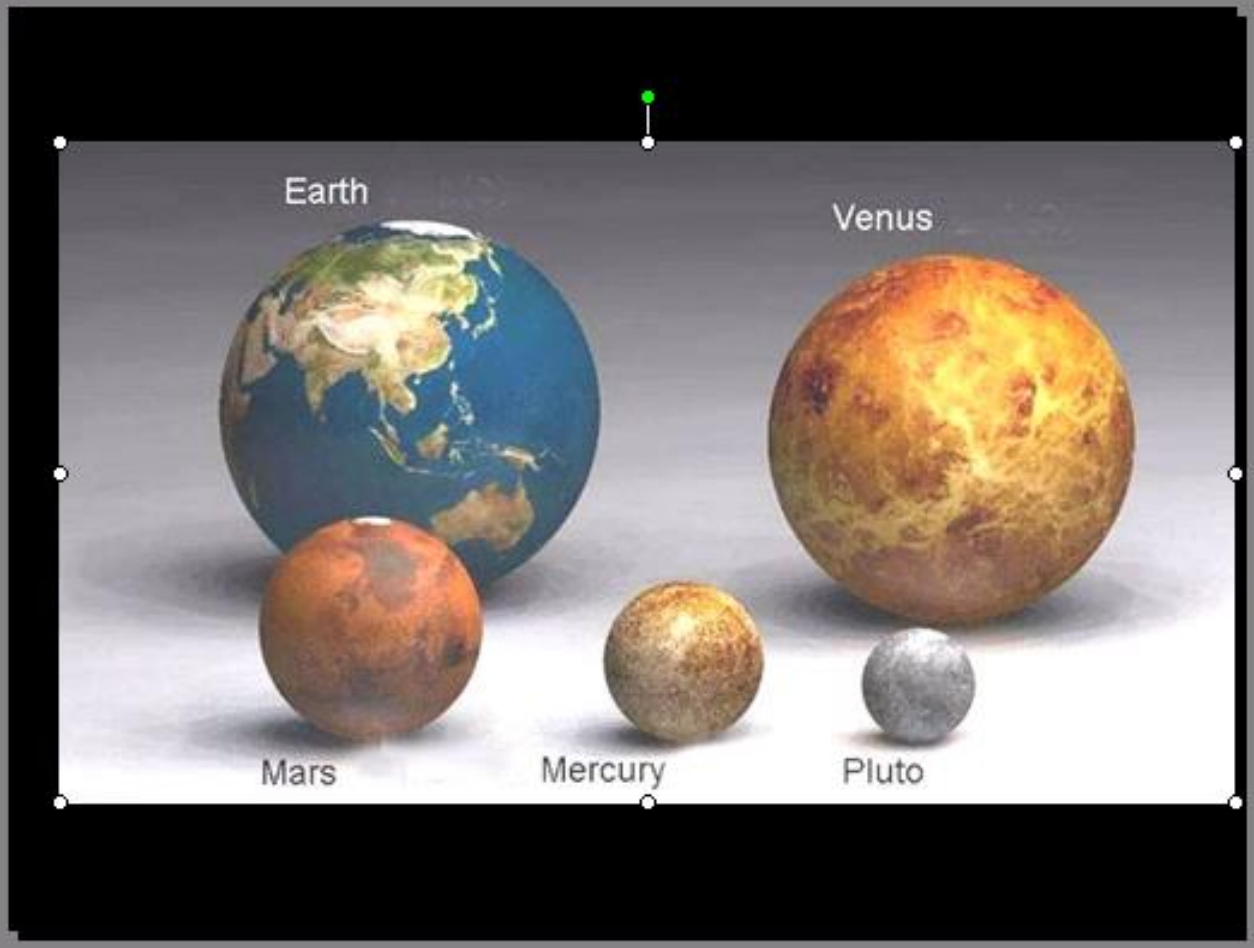
The global ocean on Jupiter's Moon **Europa** contains about twice the liquid water of all the **Earth's** oceans combined. New research by Richard Greenberg of the University of Arizona suggests that there may be plenty of oxygen available in that ocean to support life, a hundred times more oxygen than previously estimated.

Microsoft PowerPoint - [פרופורציות כדור הארץ לעומת התבל]

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Type a question for help

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Draw AutoShapes

Phoenix: "It Must Be Ice"



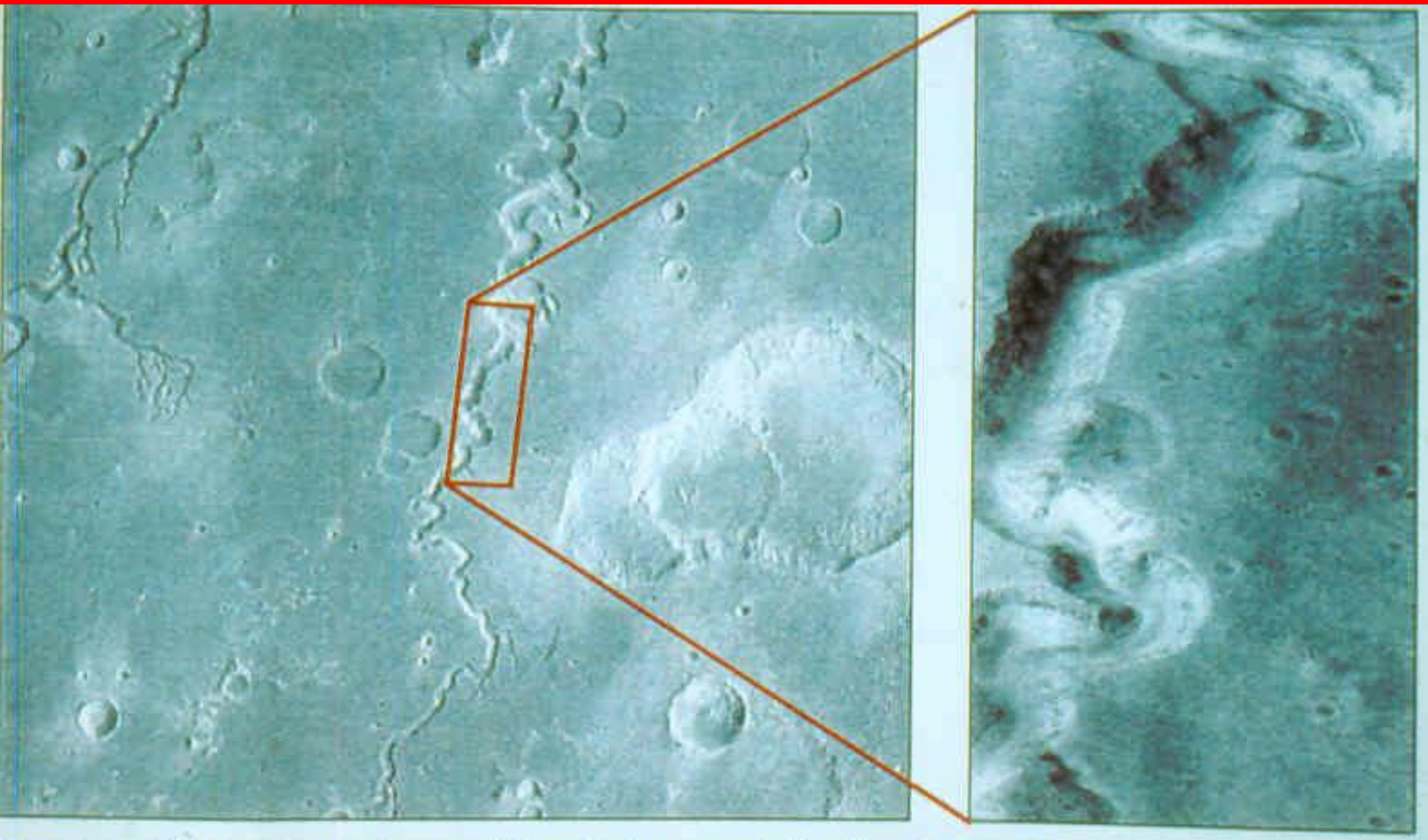


STENLEY MILLER EXPERIMENT (1953)



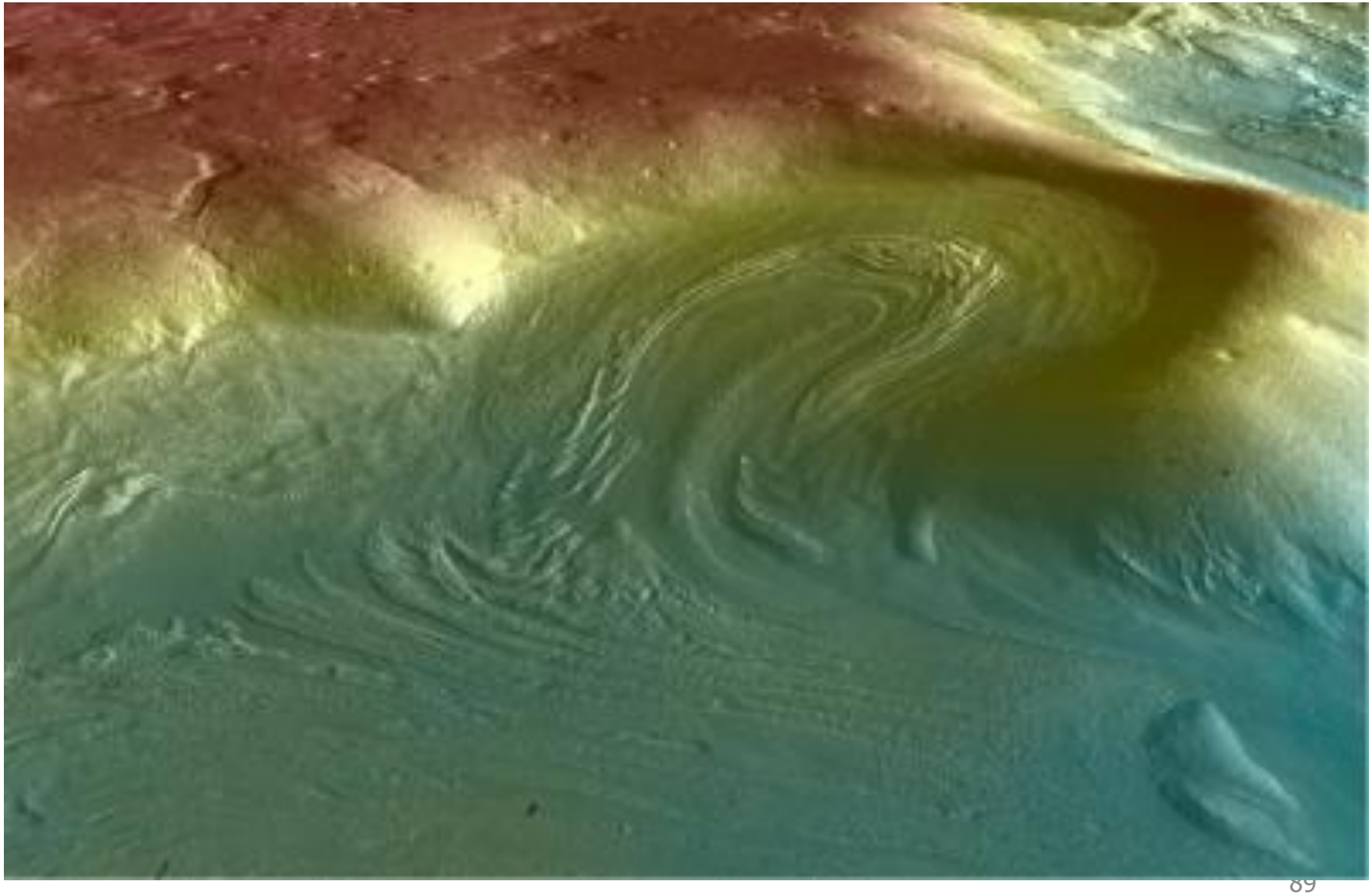
Indian scientists flying a giant balloon experiment have announced the **discovery of three new species of bacteria from the stratosphere**.





The Nanedi Valles is a feature on Mars that suggests liquid water once flowed on the surface.
Images: NASA/JPL

Recurring glaciers on the surface of Mars

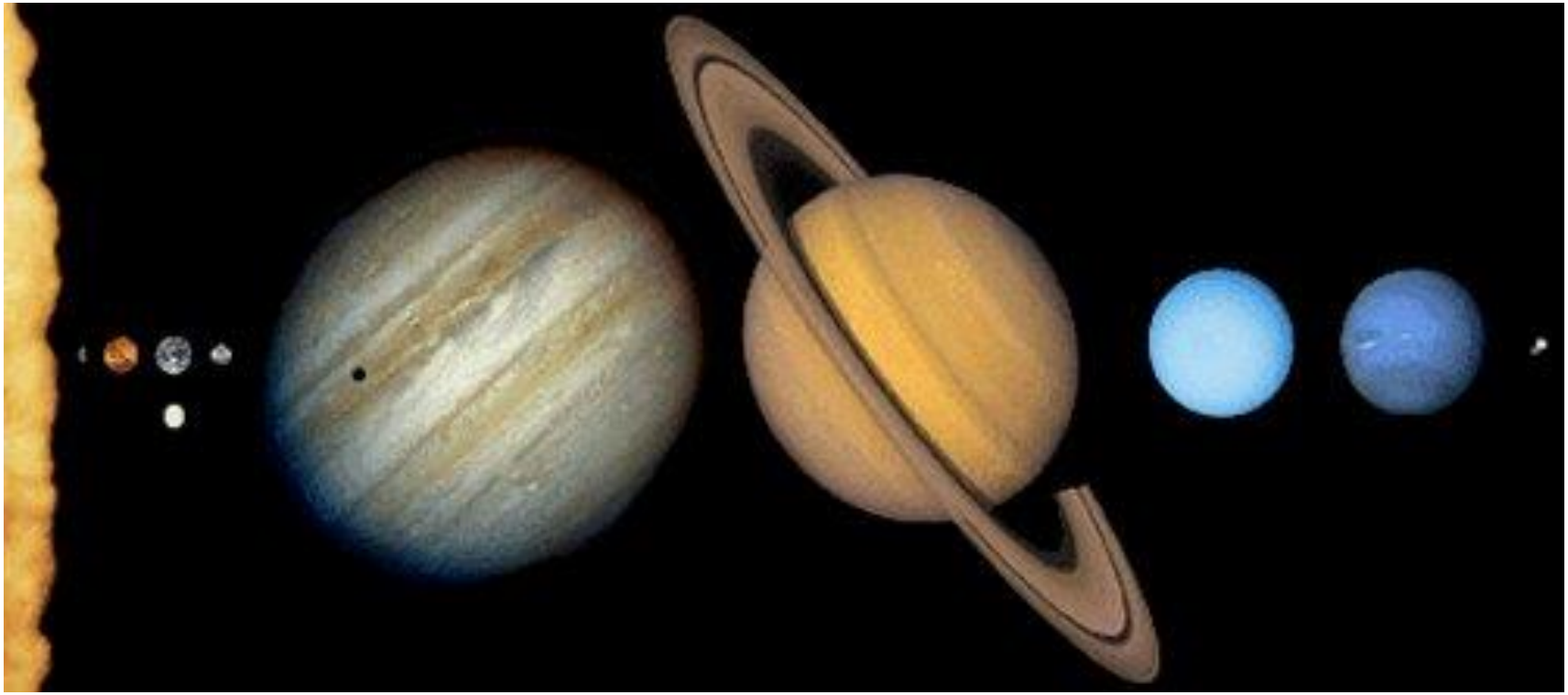


Antarctica's "Blood Falls" Shows How Aliens Might Live on Ice Worlds

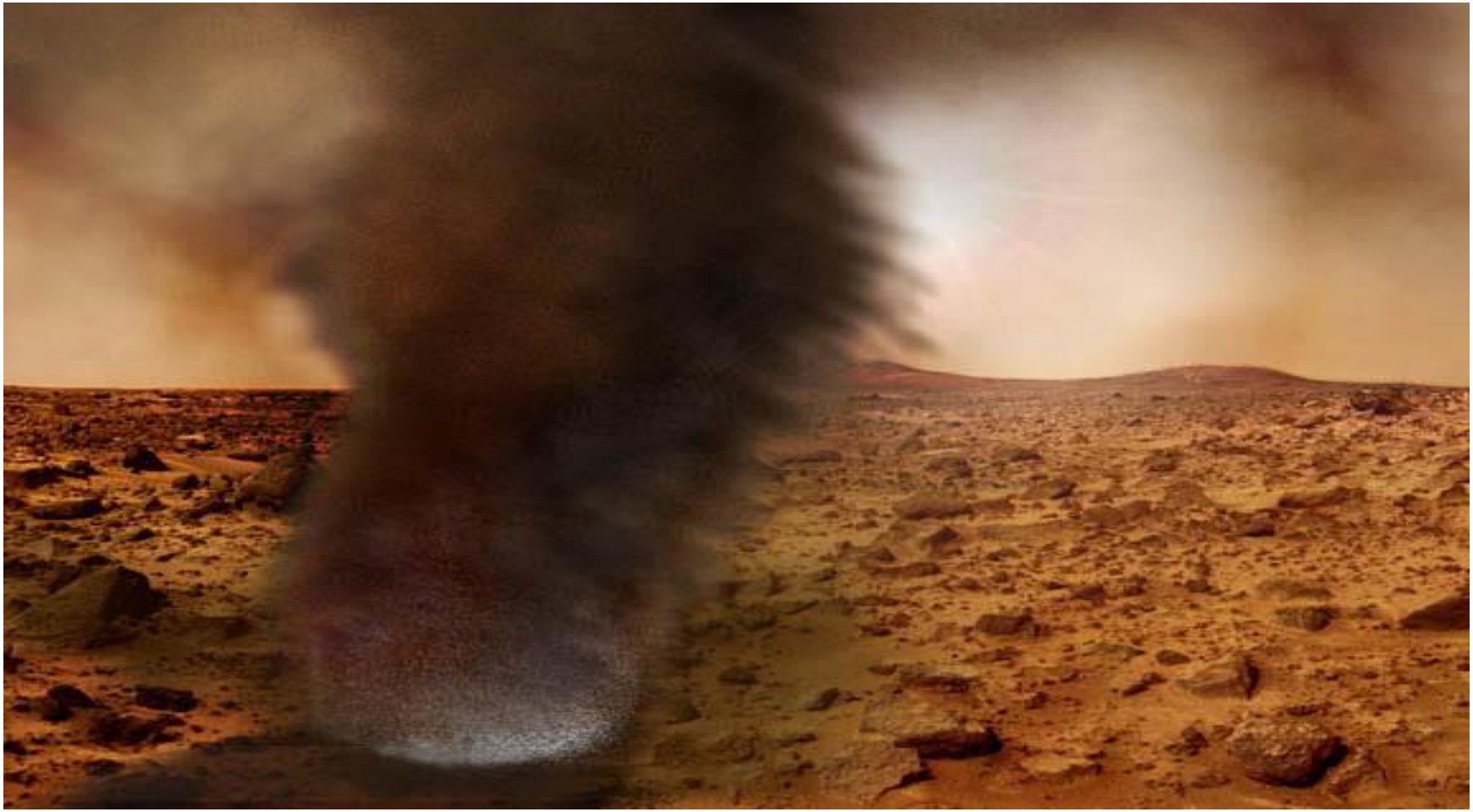


image of a water-carved channels on Mars

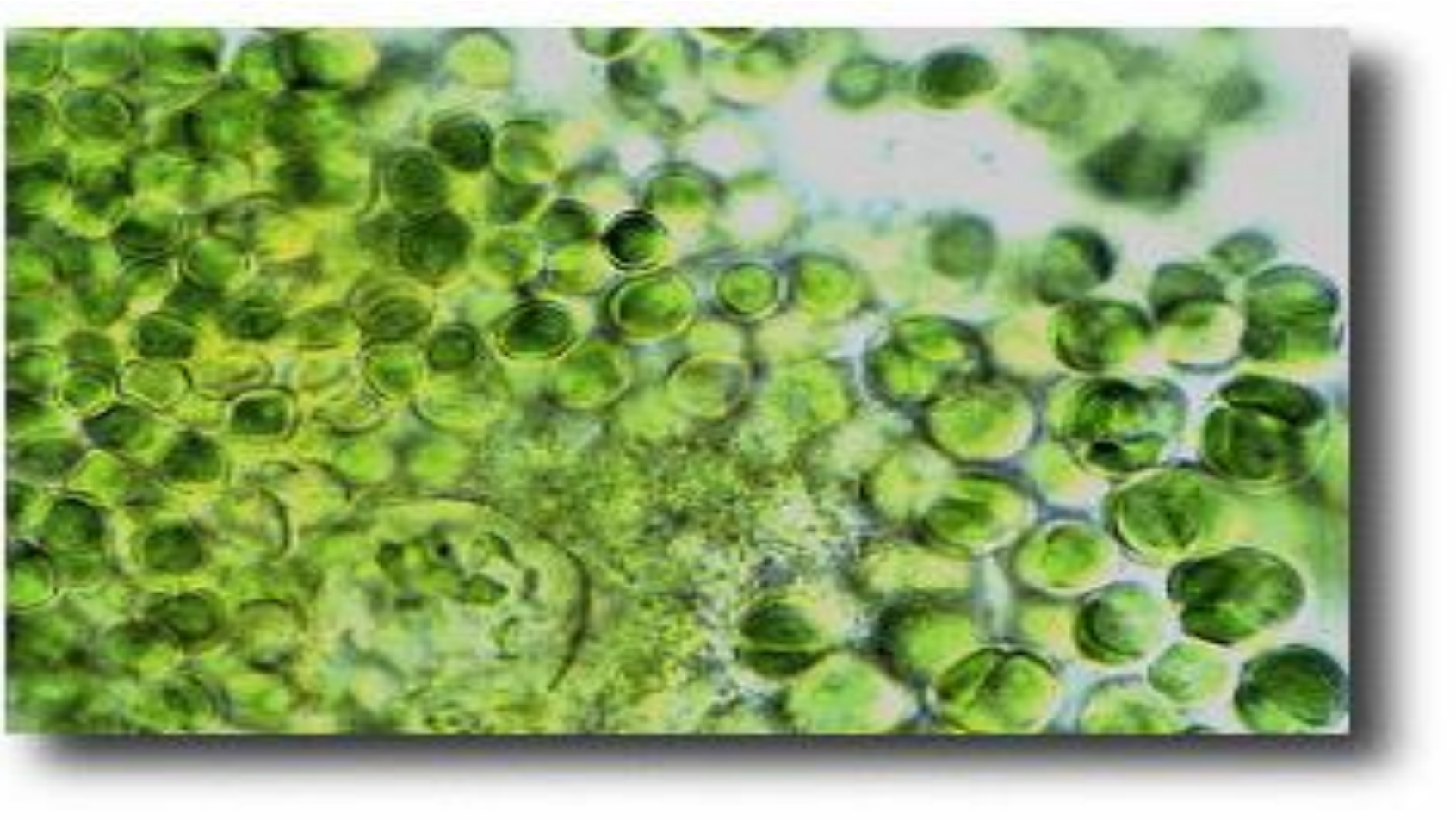




An illustration of a dust storm on Mars.



Chroococcidiopsis candidate for Martian inhabitation

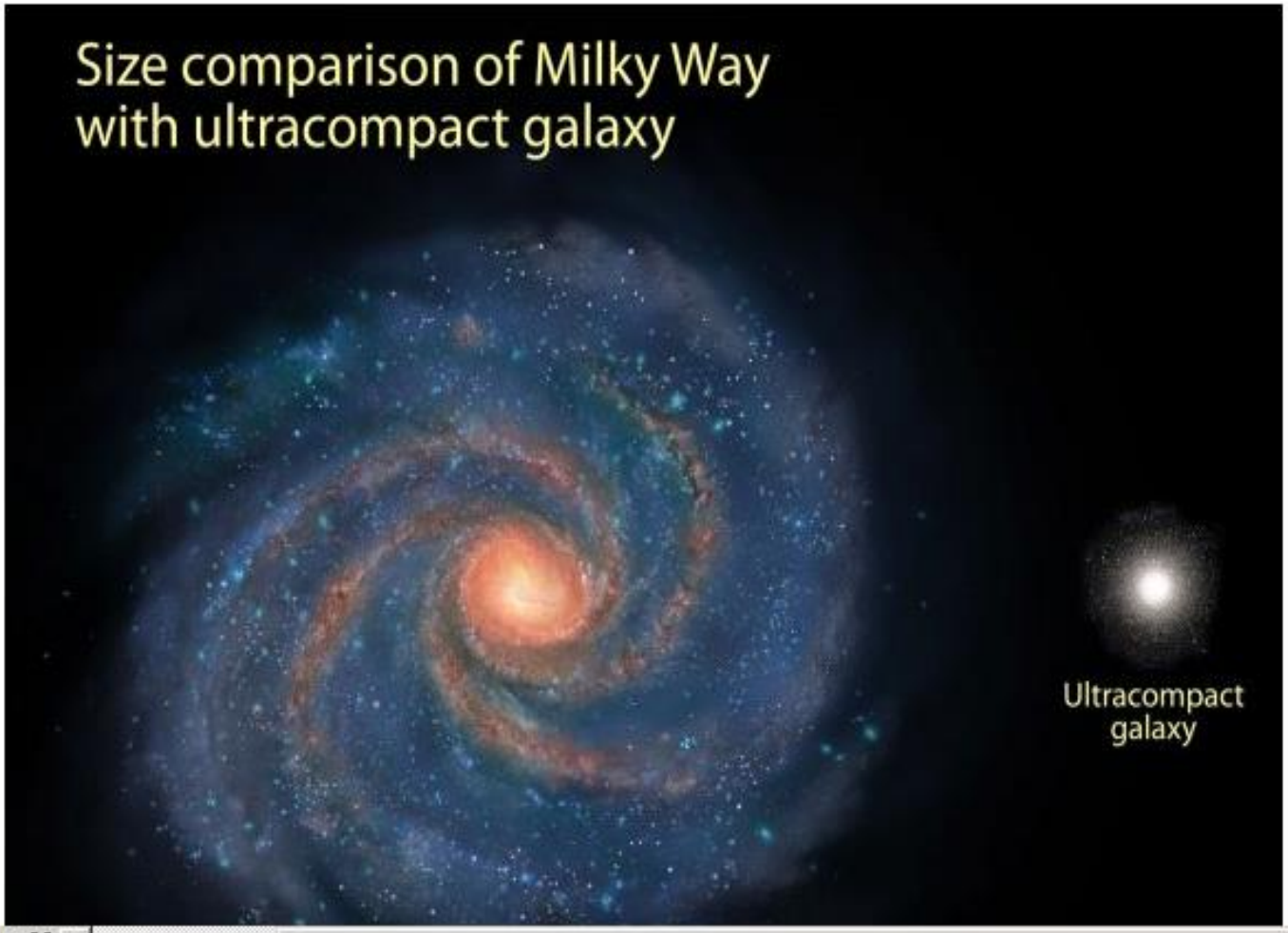


Hubble Surprise of Milkyway - Microsoft Word

Normal + Befor 100%

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Arial 9



Page 1 Sec 1 1/1 At 4.9cm Ln 4 Col 1 REC TRK EXT OVR English (U.S

QUESTIONS ABOUT ORIGINS

1) **EVIDENCE FOR THE LIFE ON EARTH?**
2) **THE STATE OF EARTH ATMOSPHERE**
3) **WHEN WAS THE ORIGIN OF LIFE ON EARTH?**
   WAS: REDUCED? HIGHLY REDUCED? NEUTRAL? OXIDIZED?
4) **WERE ASTROIDS & COMETS SOURCES OF ORGANICS?**

QUESTIONS ABOUT ORIGINS

5) WHEN WAS OXYGEN PHOTOSYN-
THESIS INVENTED?
6) WHEN DID EUKARYOTES ORIGINATE?
7) WAS THERE AN RNA WORLD?
8) WHAT WAS THE SITE OF THE ORIGIN OF LIFE? POND? OCEAN? HYDRO-THERMAL VENTS? SUBSURFACE, PANSPERMIA? MINERAL SURFACE? OR MARINE SHORELINE?

QUESTIONS ABOUT ORIGINS

9) **WAS THE FIRST ORGANISM HETERO-THROPH OR AUTOTHROPH?**

10) WAS THE FIRST CELL THERMO-PHILE or MESOPHILE or PSYCHROPHILES?

11) IS THERE LIFE IN OUR SOLAR SYSTEM OUTSIDE EARTH?

Martian Settlers May Need Chickens To Conquer The Red Planet

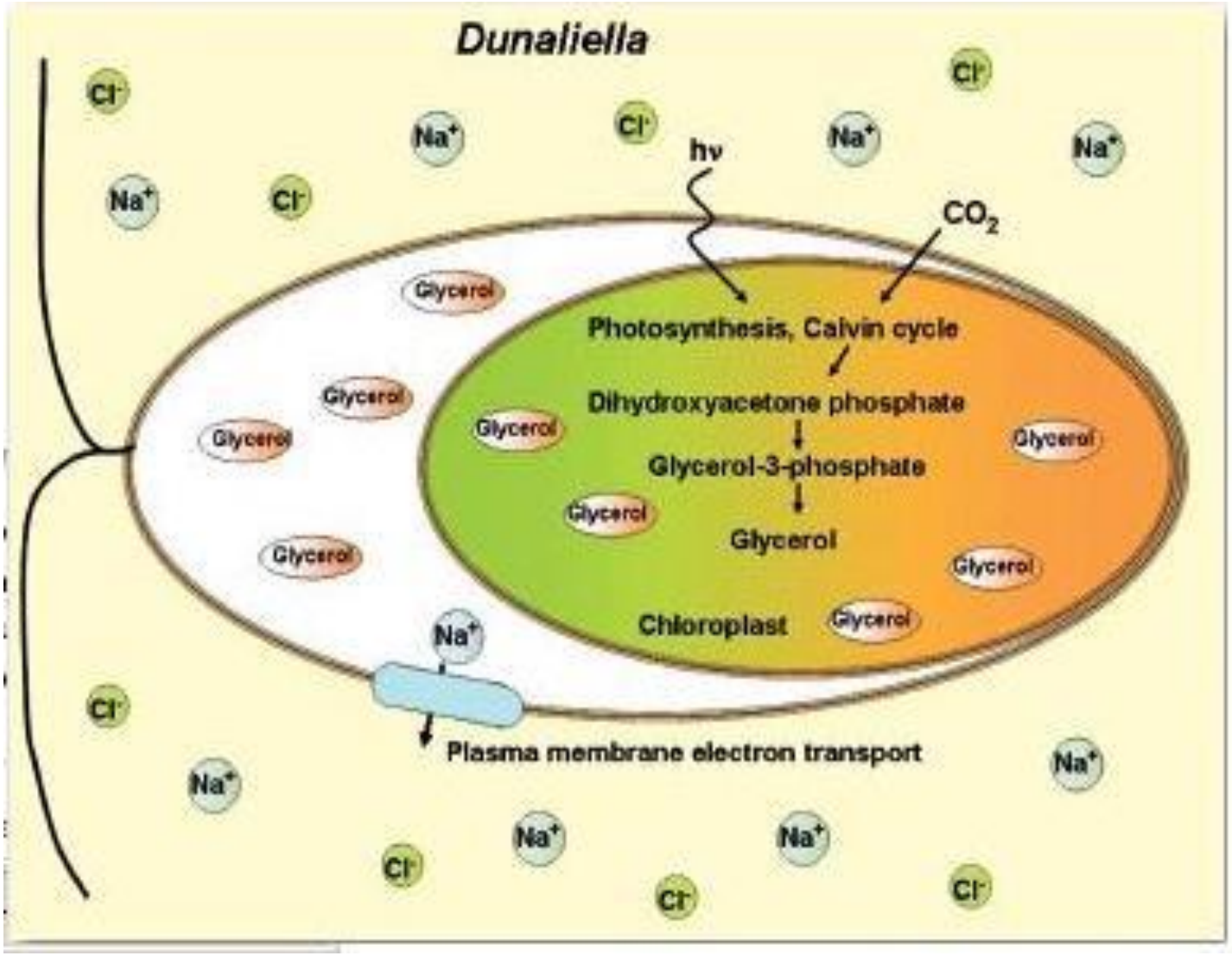


- If humanity ever intends upon on settling Mars (by settling We mean a one way trip with no plans on returning back to Earth), they are going to need a whole lot of chickens if they want to survive–let alone thrive–upon the red planet.

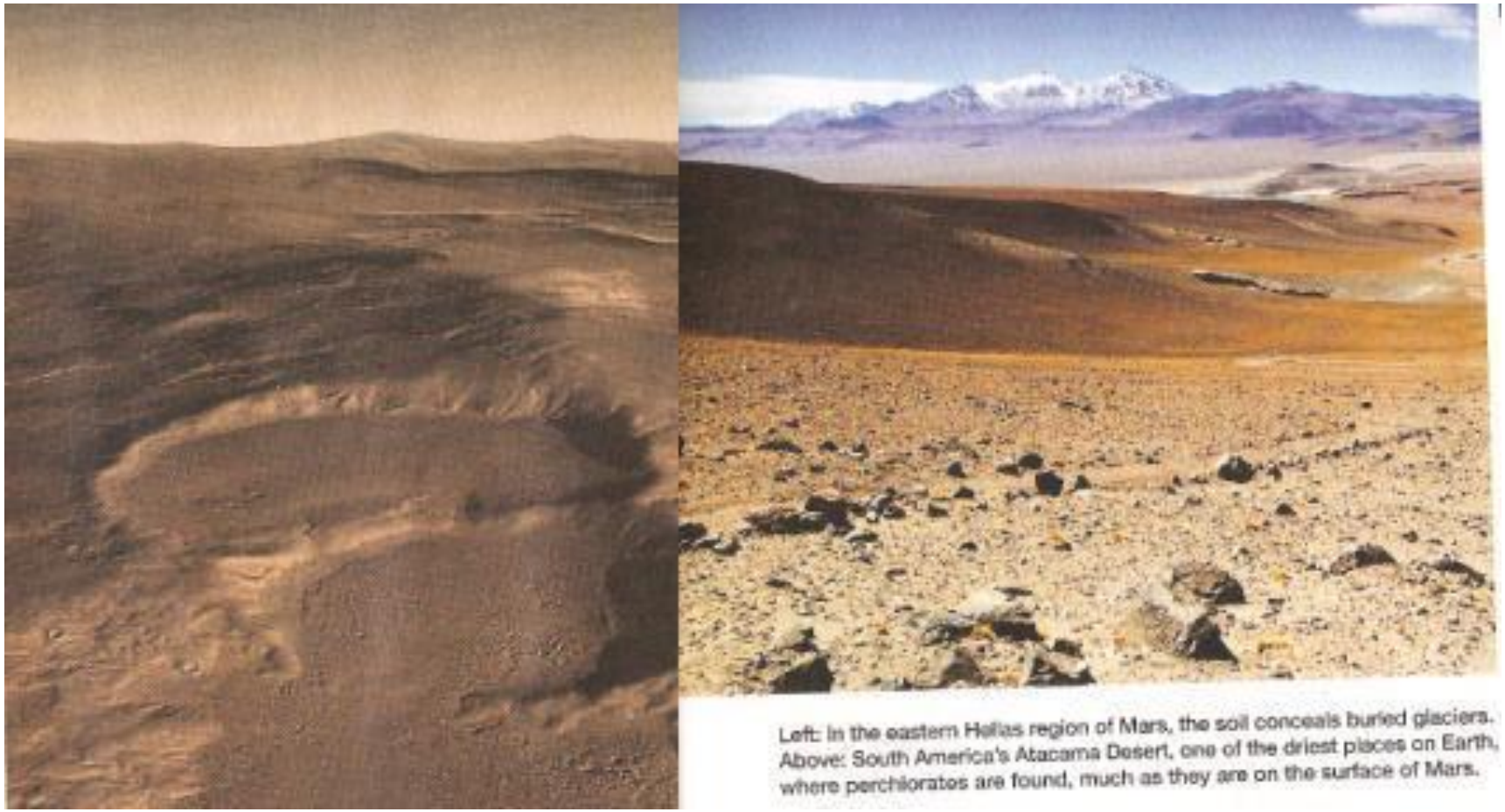
Europa Submarine Prototype Gets Another Test

A submersible probe that could possibly be used on Jupiter's icy moon, **Europa** is taking the next step to test its capabilities. The Environmentally Non-Disturbing Under-ice Robotic Antarctic Explorer, also known as ENDURANCE, will swim untethered under ice, and collect data to create **three-dimensional maps** of **underwater environments**. The probe also will take **samples of microbial life**. Now it will plunge under a permanently ice covered lake in Antarctica that is 40 meters deep.

Dunaliella metabolism



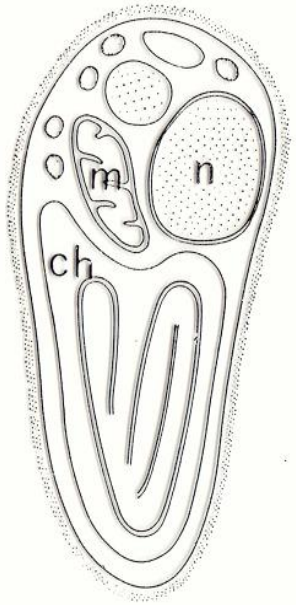
Mars vs. Atacama in Chile



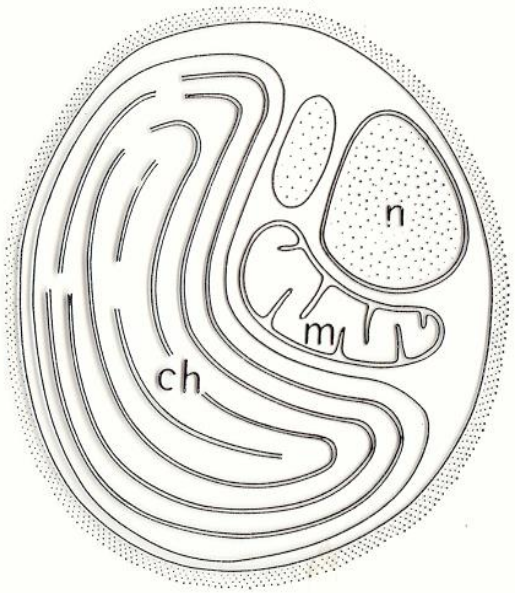
Left: In the eastern Hellas region of Mars, the soil conceals buried glaciers. Above: South America's Atacama Desert, one of the driest places on Earth, where perchlorates are found, much as they are on the surface of Mars.

Evidence of water (ice) on Mars ?

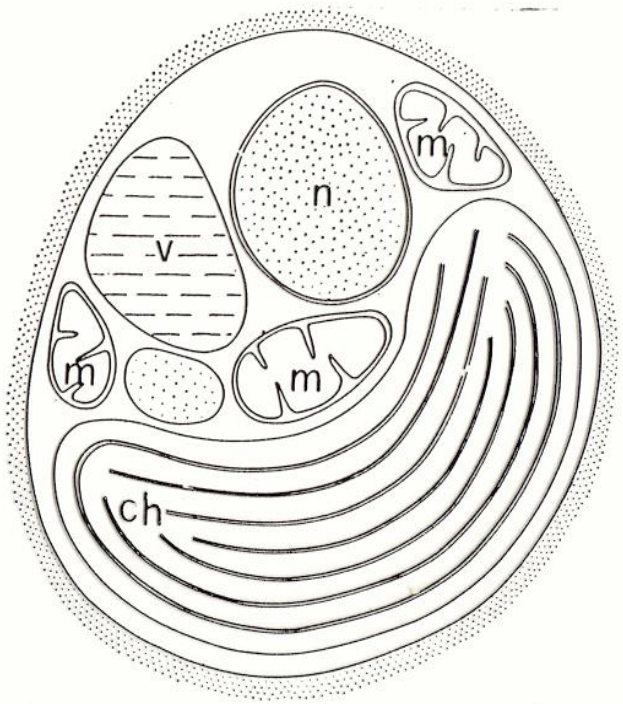




Cyanidioschyzon merolae De Luca, Taddei & Varano;



Cyanidium caldarium Geitler;



Galdieria sulphuraria (Galdieri) Merola.

Fig. 1 — A sketch showing the main ultrastructural characteristics of three thermal acidophilic algae: a) x ca. 13,000. ch. = chloroplast; m = mitochondrium; n = nucleus; v = vacuole.

DISCOVER

Science, Technology, and The Future

THE 5-YEAR ENERGY FIX

HOW WE WILL Clean Up Coal, Reboot Nuclear Power, Capture Sunlight, and Rewire the Economy

PLUS Dog Doctors, Rat Love, Methane Rain on Titan, and How Climate Change Made Us Human

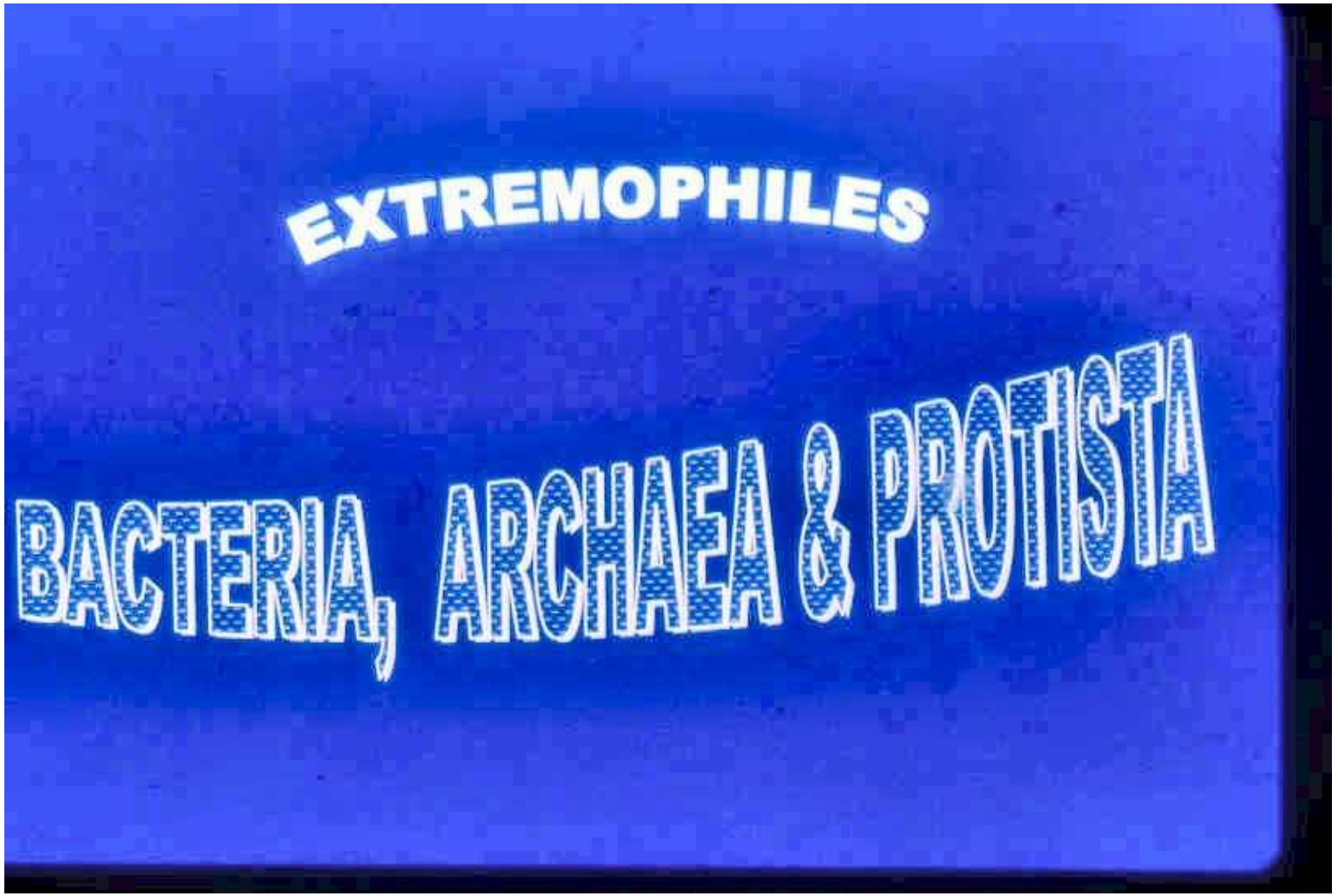
HAVE WE ALREADY FOUND LIFE ON MARS?

THE ENIGMA OF SPECIES

DARK GALAXIES

GOOD PROTEINS GONE BAD

$5.99 U.S.


EXTREMOPHILES
BACTERIA, ARCHAEA & PROTISTA

Life Found a Mile Below Terrestrial Seabed;

Implications For Life on Mars



Chroococcidiopsis [CB] in rocks (Negev IL)



From Fossils to Astrobiology

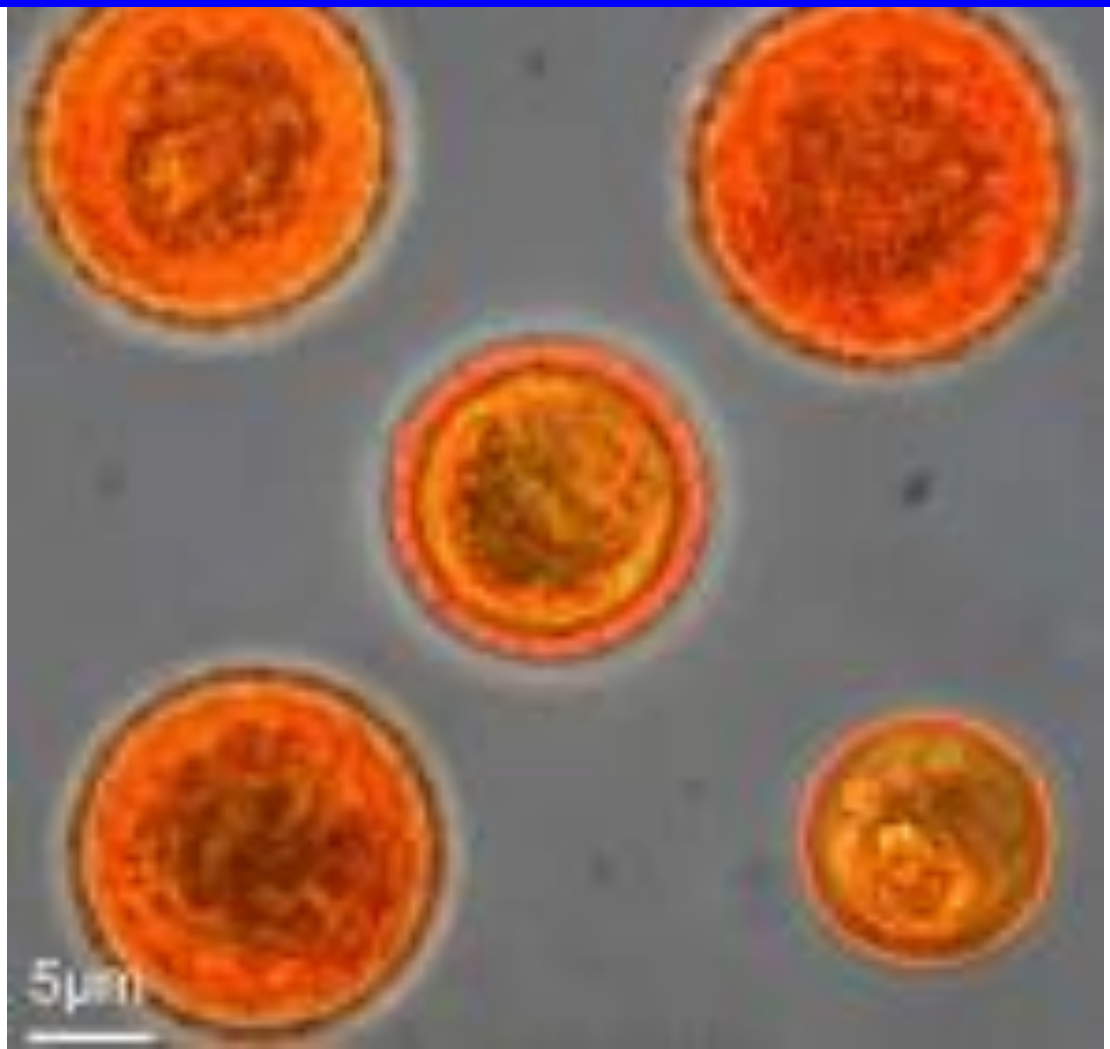
Records of Life on Earth and the Search for Extraterrestrial Biosignatures

Edited by
Joseph Seckbach and Maud Walsh



Springer

Dunaliella rich carotene (as osmotic balance)



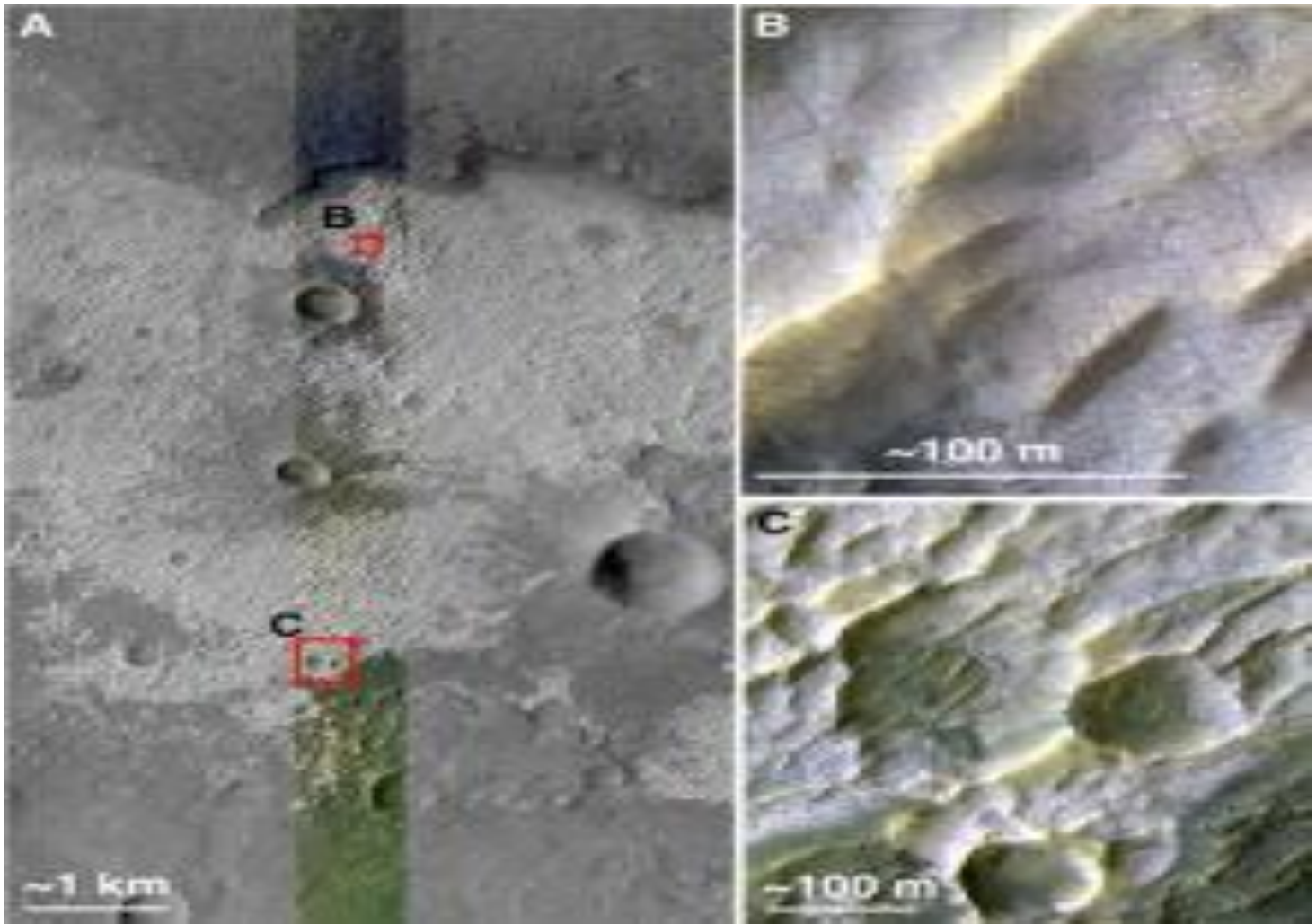
TARDIGRADE [water bear]
a Multicellular Extremophile







Salt Deposits on Mars Might Be the Right Place to Search for Life



Phoenix Camera Snaps Frost on Mars



Cyanidium grown on pure CO_2 and on Air

Cell volume and released photosynthetic O_2

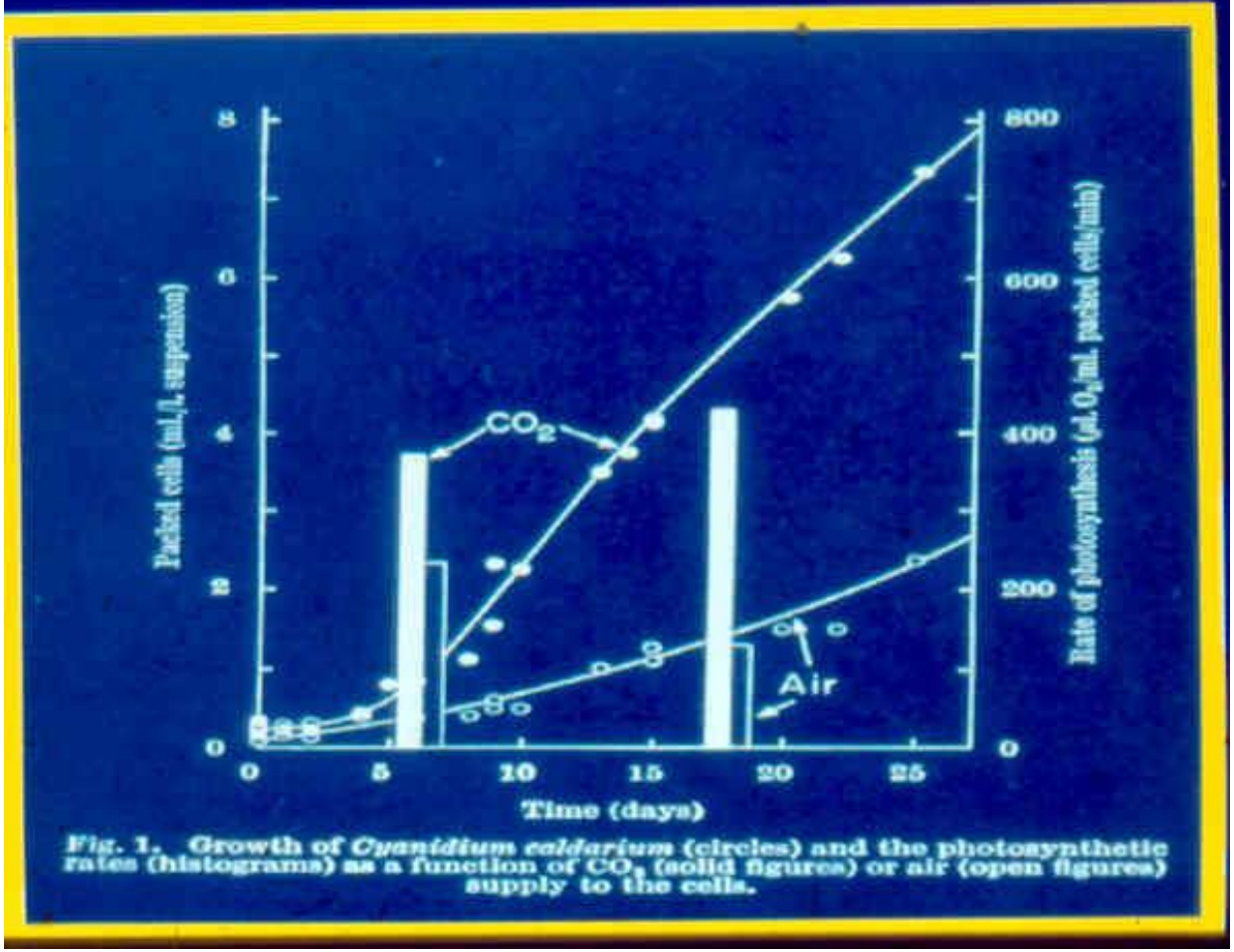
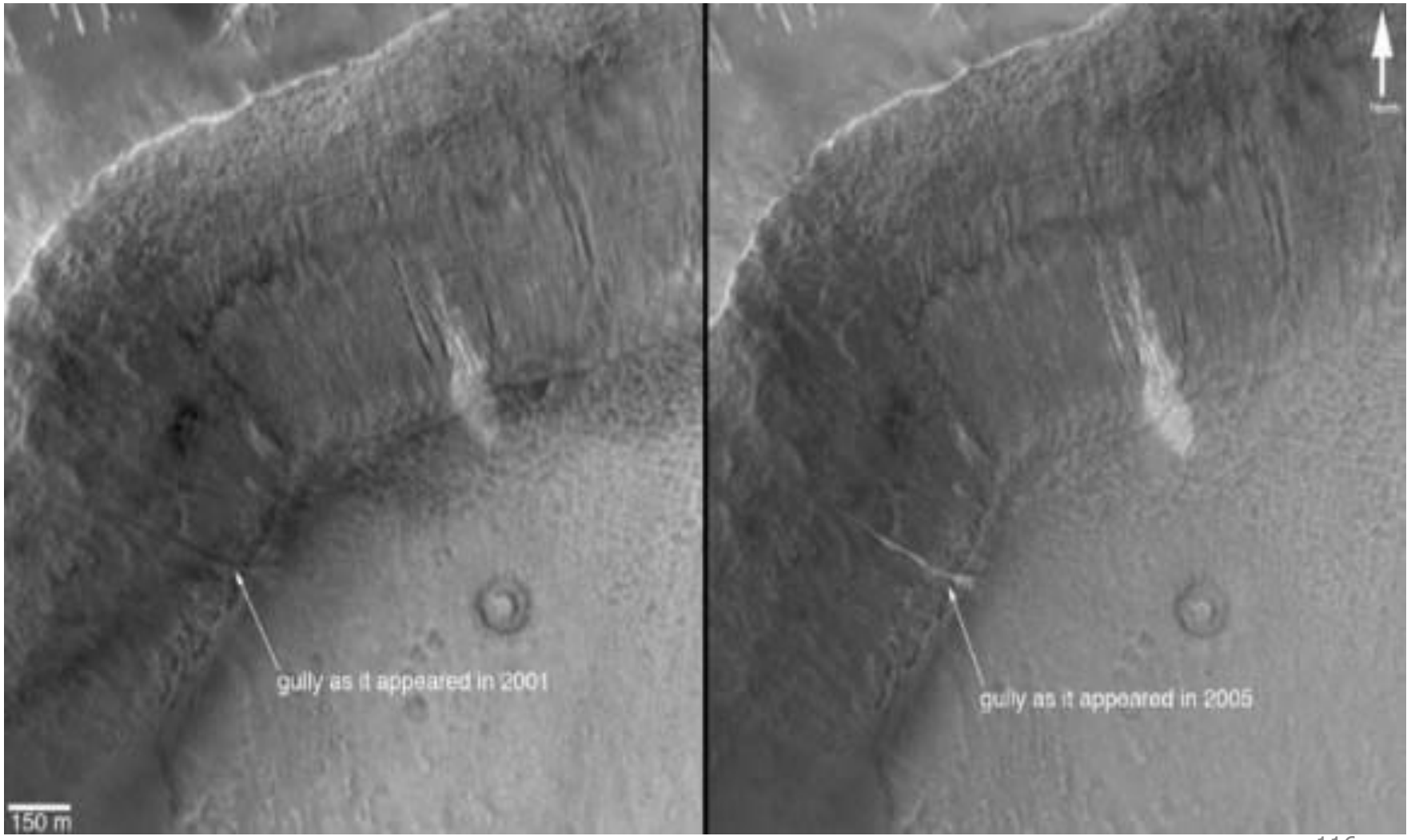


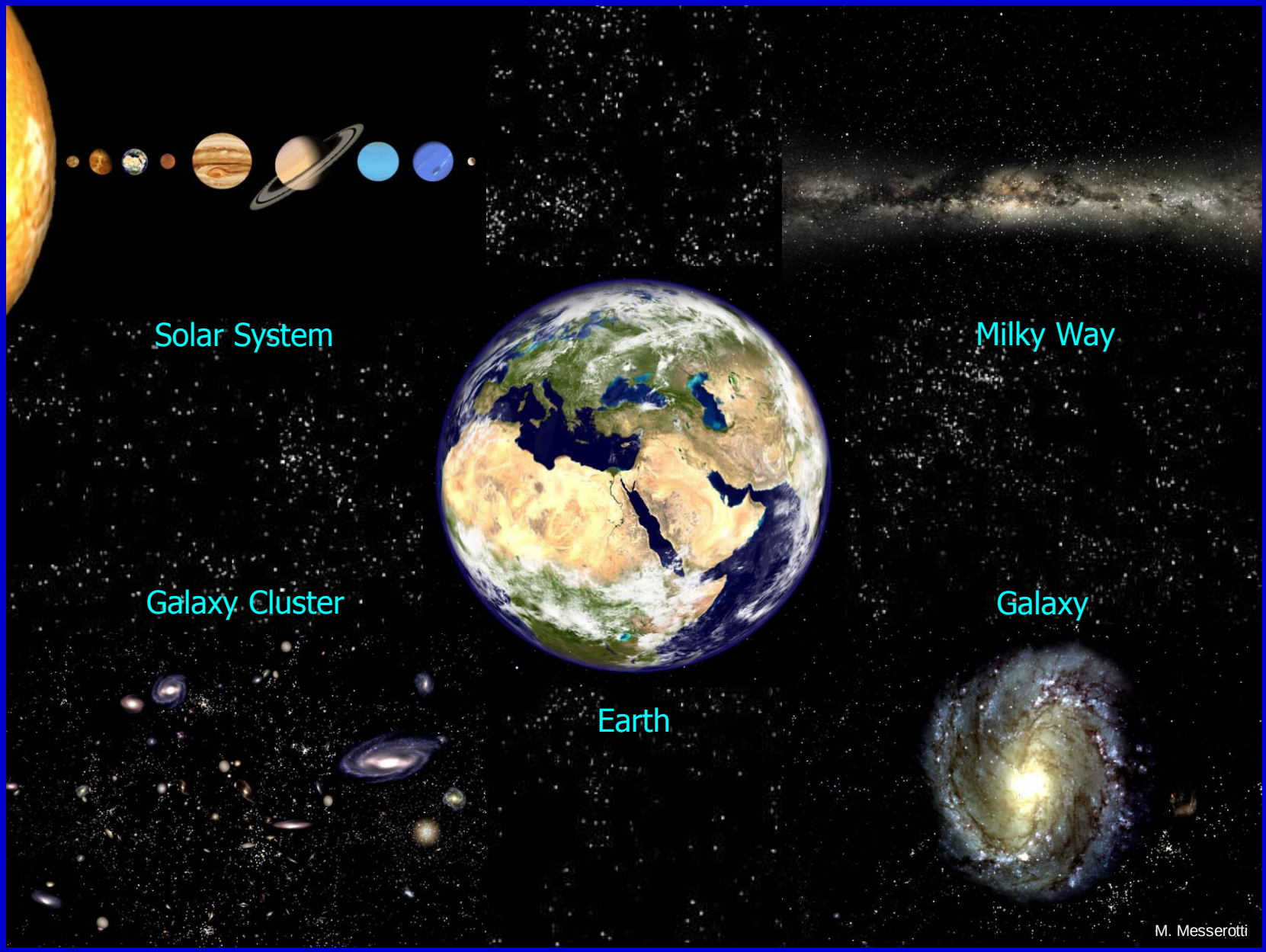
Fig. 1. Growth of *Cyanidium caldarium* (circles) and the photosynthetic rates (histograms) as a function of CO_2 (solid figures) or air (open figures) supply to the cells.



FIGURE 8. This cell was cultured heterotrophically in dark with glucose. There is a drastic reduction in the plastid size (P); they barely contain lamellation. It undergoes cellular division: the separating outline of the two daughter cells is already being formed (S) and it splits the cell into two regions. Both nuclei (N) contain chromosomes and the nucleolus is present (Nu), the nuclear envelope is not complete and it seems to open up to the cytoplasm (arrows), a microtubule is visible (arrow head). Some mitochondria are seen to divide in both regions (M). ×15,000.

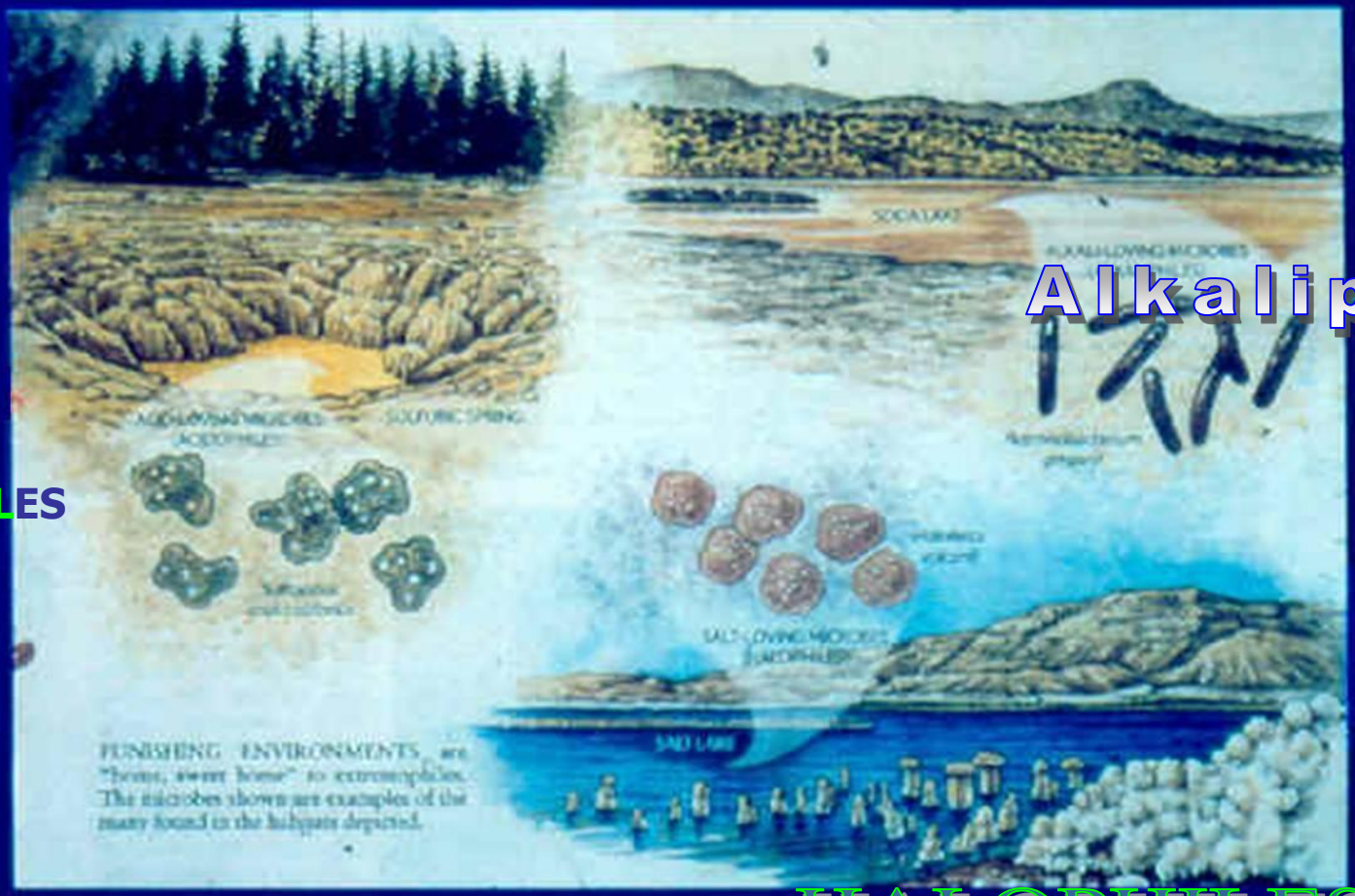
Are Gas-Formed Gullies the Norm on Mars?





Courtesy of Professor Mauro Messerotti – Trieste

Extremophilic Microorganisms



Alkaliphiles

ACIDOPHILES

HALOPHILES

Life on Mars Theory Boosted by New Methane Study

- **Scientists have ruled out the possibility that methane is delivered to Mars by meteorites, raising fresh hopes that the GAS MIGHT BE GENERATED BY LIFE on the RED PLANET, in research published in *Earth and Planetary Science Letters***
  - ***Science Daily (Dec. 8, 2009)***

NASA Finds Shrimp Where No Advanced Life Should Be: 600 Feet Beneath Antarctic Ice

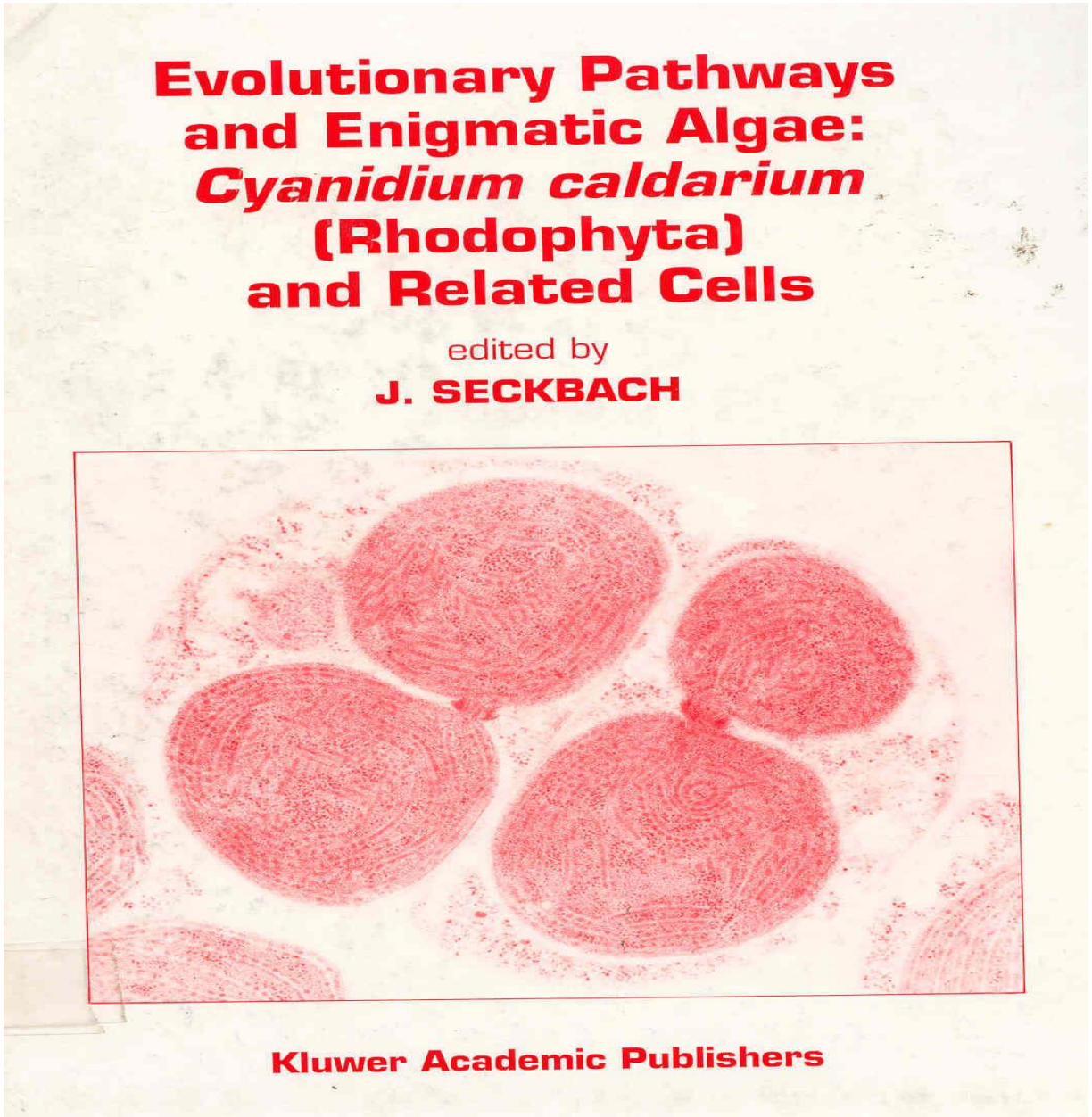


MOTHER EARTH-OUR PLANET




They're
reaching
for the stars...

THE CYANIDIUM BOOK

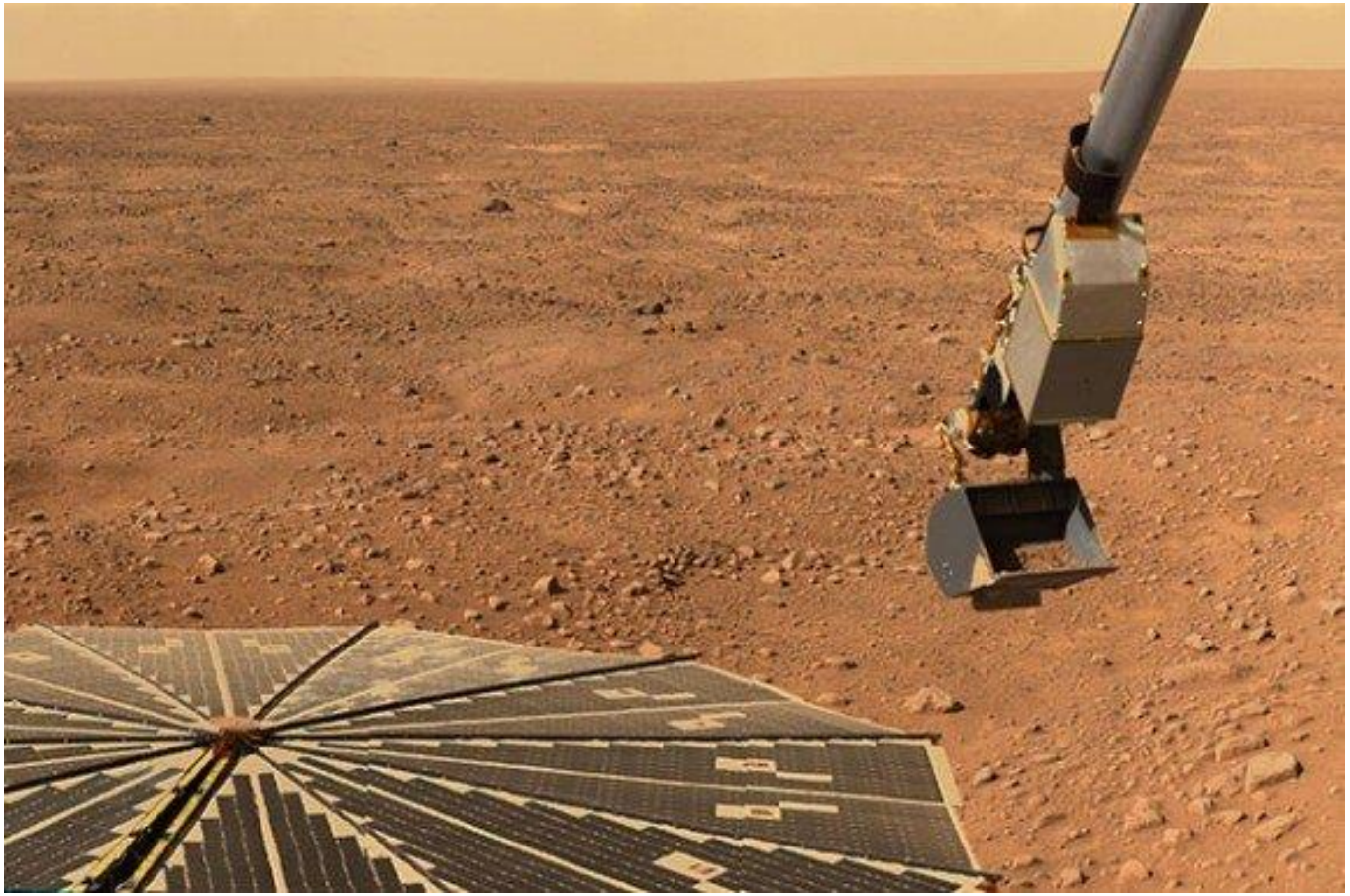


Movement of Tardigrade



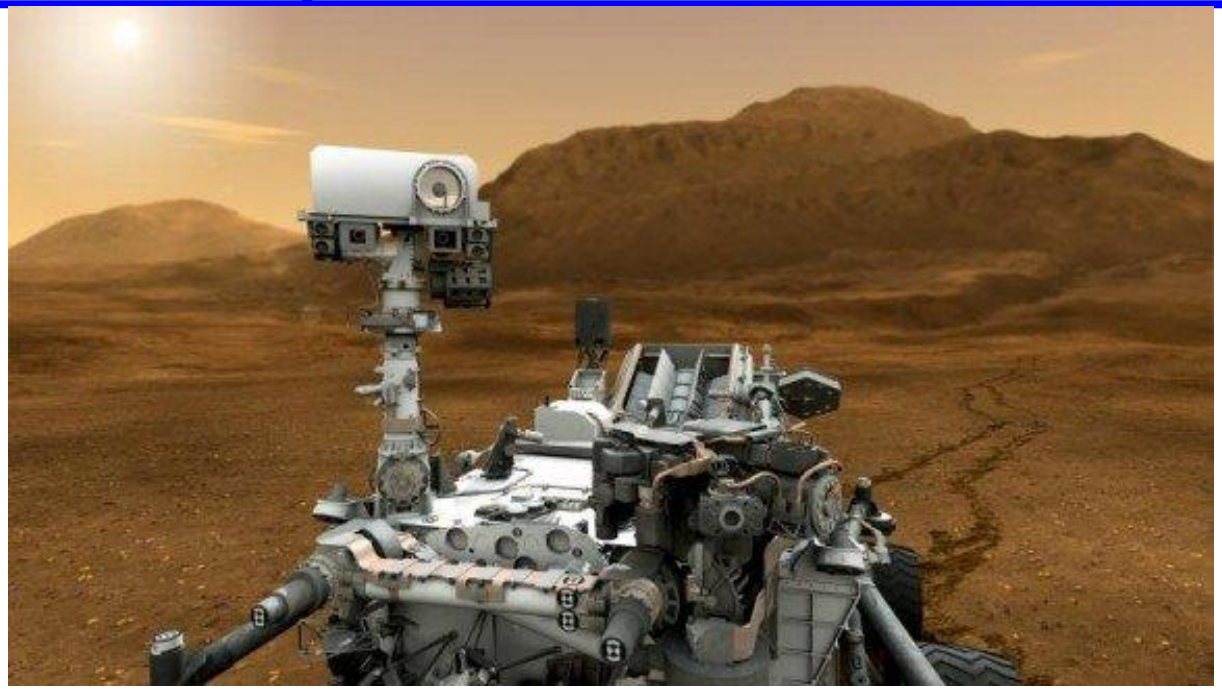
600 Million Year Drought Makes Life on Surface of Mars Unlikely

View of Mars' surface near the north pole from the Phoenix lander



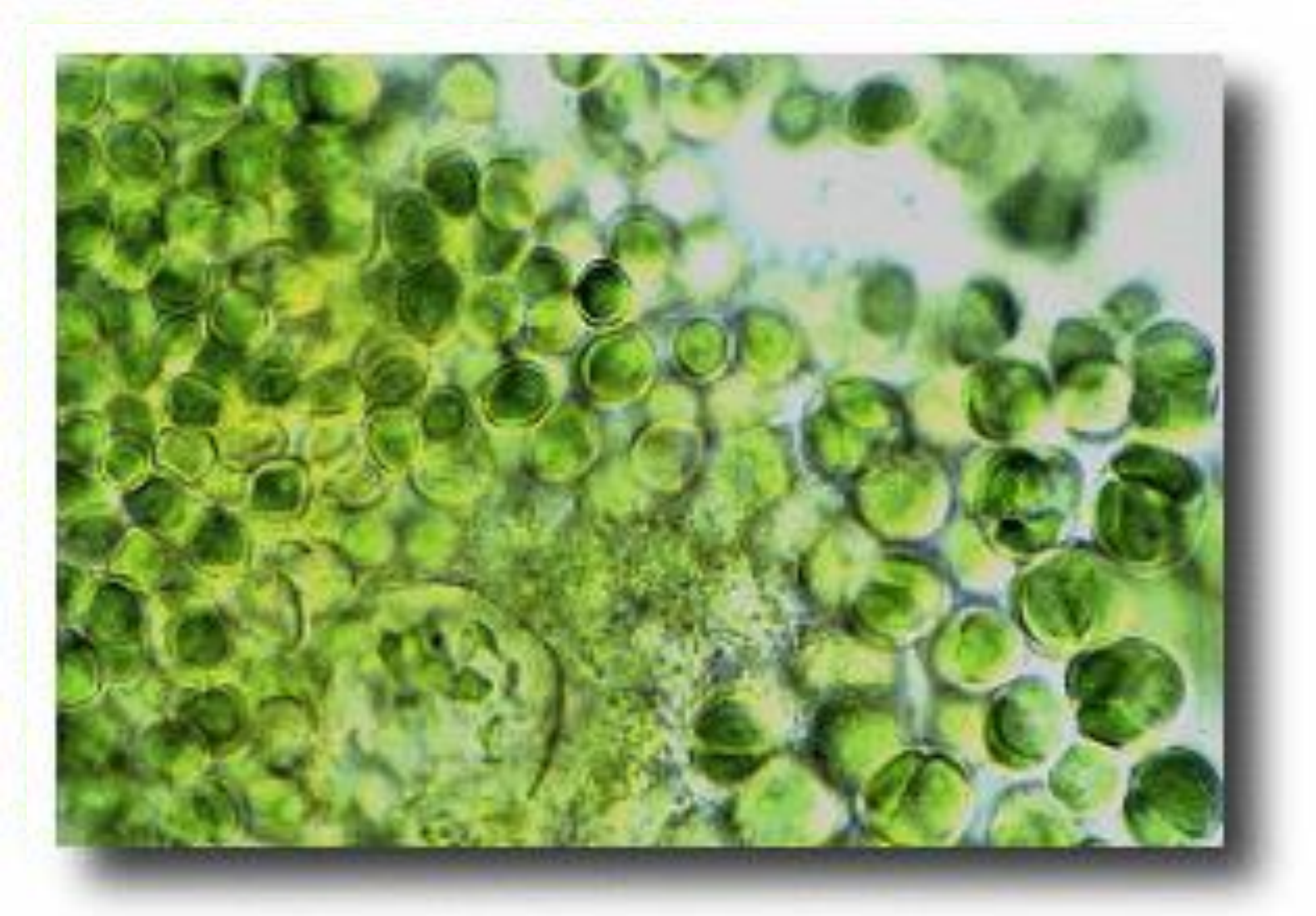
Credit: NASA/JPL-Calech/University of Arizona

Curiosity Starts First Science on Mars Sojurn – How Lethal is Space Radiation to Life's Survival



*NASA's Mars Science Laboratory Curiosity rover is currently cruising to Mars and is already investigating the lethality of the interplanetary space **radiation environment** to humans. After touchdown, Curiosity will*
investigate Mars' past or present ability to sustain microbial life.
Credit: NASA/JPL-Caltech

Chroo-coc-cidiopsis (-20C -->+20C, desiccation, candidate for Astrobiology)



"YOGI" rock on Mars (5 m)



Blood Falls at Antarctica's Taylor Glacier.



STROMATOLITES FROM AUSTRALIA

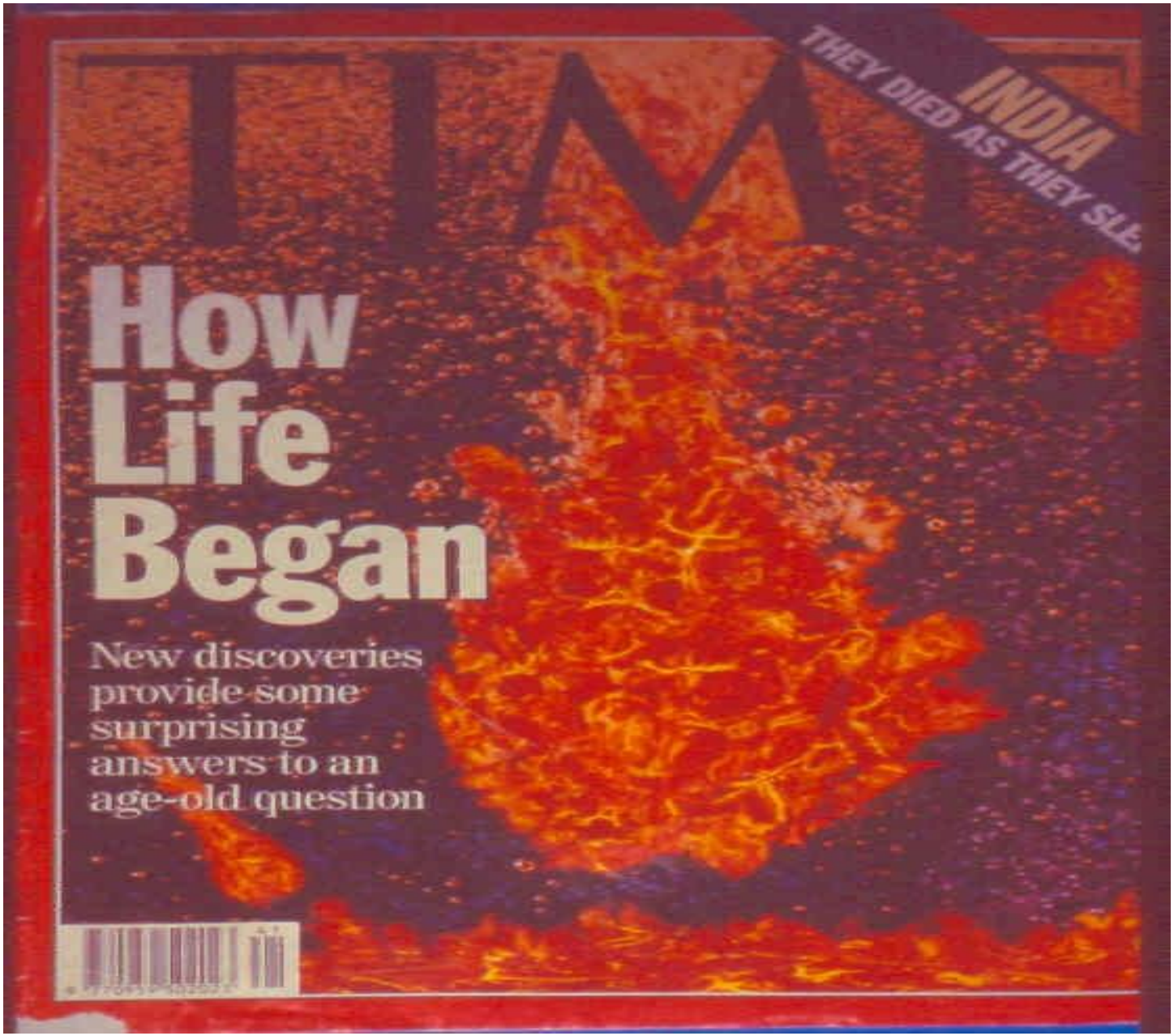



TART ?
HYDOROTHERMO VENTS

HOSTILE VOLCANIC LAKE TEEMS WITH LIFE

Microbes thriving in salty, alkali waters containing arsenic.

- **Published online 2 April 2010 [Nature]**


INDIA
THEY DIED AS THEY SLE
How Life Began
New discoveries provide some surprising answers to an age-old question

MICROBIAL DIVERSITY

HALOPHILES

- SALINITY (g/l)

0 350

< Eukaryotes – Prokaryotes >

F.W. ORGANISMS EXTREME HALOPHILES

Brackish,marine

Salt lakes

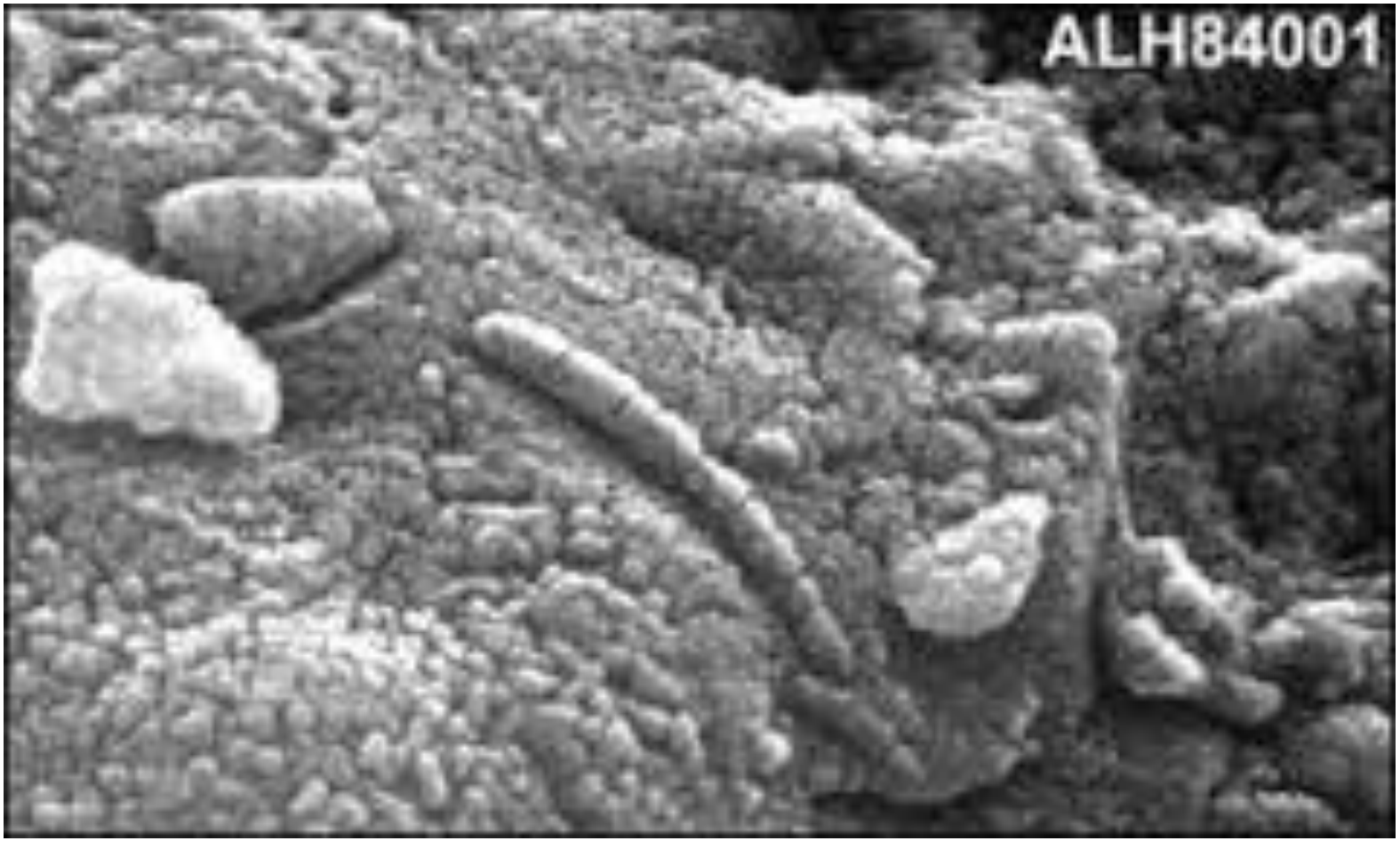
Dead Sea

Mother Earth



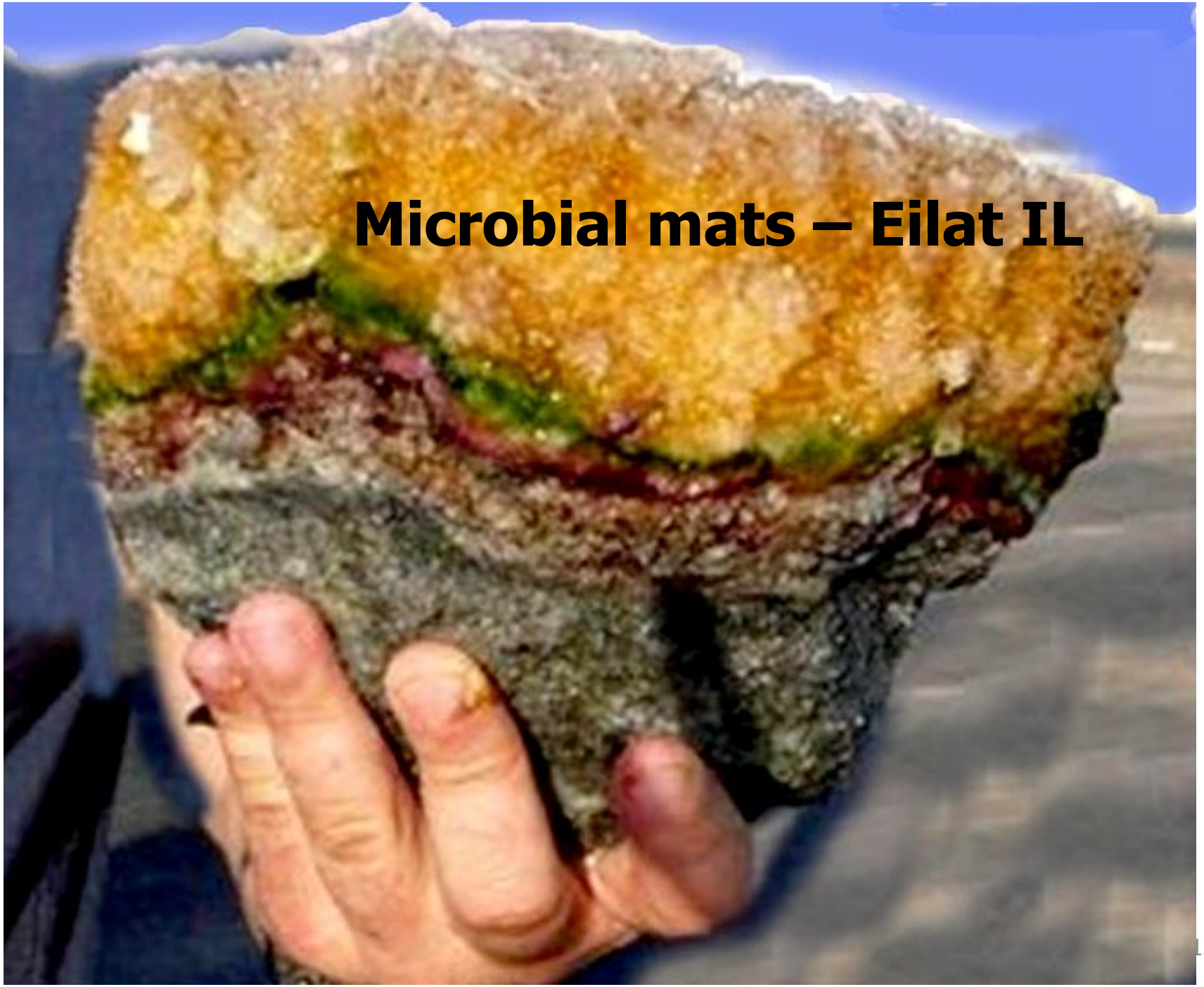
NANOBACTERIA FROM MARS

BIOFOSSILS OR INORGANIC MINERALIZATION?



GREENING OF THE RED PLANET [Terraforming]

A hardy microbe from Earth might one day transform the barren ground of Mars into arable soil.


Microbial mats – Eilat IL

Chroo-coc-cidiopsis (-20C -->+20C, Cyanobacteria-desiccation, candidate for Astrobiology)

