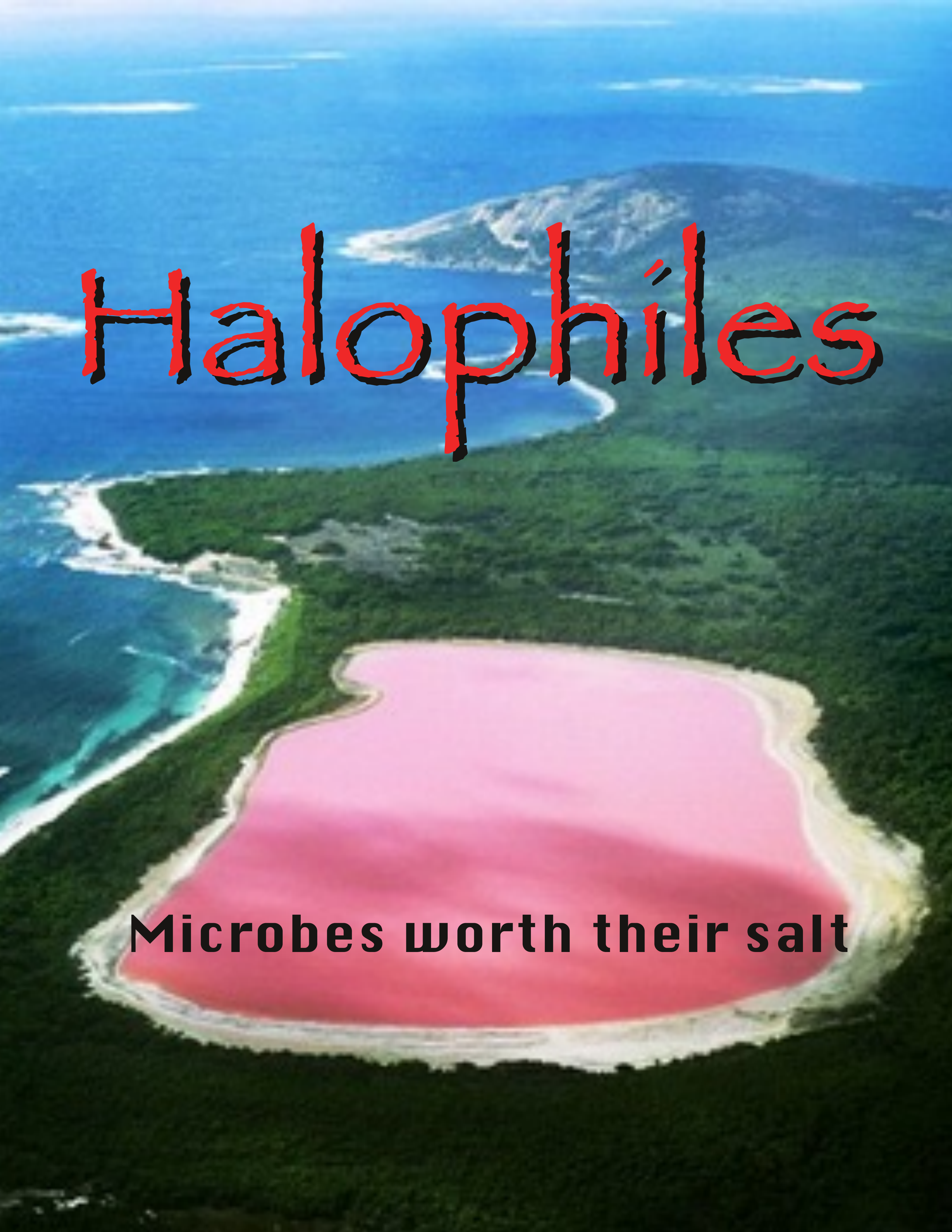
Halophiles



Microbes worth their salt

Great Salt Lake, Utah. A railroad causeway runs across the lake that limits circulation between the northern and southern arms of the lake. The northern arm has less freshwater input and so is saltier allwoing the purple halophiles to prosper and so color the water.

Halophilic ("Salt-loving") microbes live in salty places. Seawater is salty, but not salty enough for halophiles. They need salt concentrations like those found in the Great Salt Lake in Utah in the United States or in the Dead Sea. Very few other things live in these environments. At the lower concentrations of these high salt environments you might find some algae and brine shrimp, but at the highest concentrations, near where salt crystals begin to form, the extreme halophiles are the only life.

At the very highest concentrations, only microbes that belong to the group called archaea live. These were the first archaea isolated in a laboratory, back in 1919. Archaea were not known to be a distinct group of microorganisms then, so they were classified as bacteria. They were isolated from rotting salted fish. Pink and purple spots of slime were found on the surface of the fish and microbes were seen to be causing these when they were examined under a microscope. Similar microbes were found in the salty ponds used to make the salt used to preserve the fish. These ponds became red, pink or purple as the water evaporated away, leaving the salt behind. Sometimes the salt itself was colored by the microbes.

Naturally salty waters are found around the world where sea water is trapped and evaporates. Inland, salty waters appear in regions with salt-rich minerals where waters that dissolve those minerals get trapped with no outflow. This is how the Great Salt Lake and the Dead Sea get salty.

Recently, unusual salty places have been discovered. In Antarctica, some lakes on the surface remain ice-free because the waters are so salty. Those lakes form like the inland salty lakes form, by dissolving minerals that surround the lake.

Salt evaporation ponds, San Francisco, California

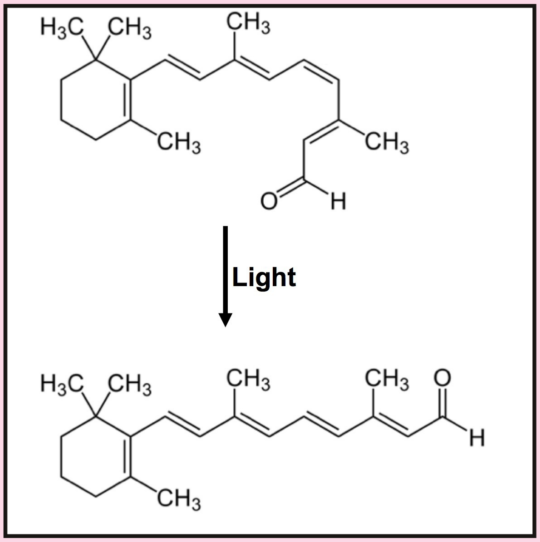
Salty ponds are also found on the seafloor in the Mediterranean Sea and the Gulf of Mexico. In these locations, salty layers of rock underly the seafloor and the surface of the floor has eroded to allow seawater to dissolve the salt. Water in these depressions in the seafloor becomes much saltier than seawater, which makes it heavier and so it stays isolate in the depressions, not mixing with the seawater above. When submersibles discovered these, they were found to look like ponds on the bottom and light from the submersibles reflected off the denser waters of the ponds. Halophilic archaeal microbes live in these ponds as well as some microbes that belong to the eukaryotes, the same group of organisms as humans. These were the first non-photosynthetic microbes to be found to live in such high salt concentrations and they are even anaerobes, incapable of using oxygen.

Owens Lake, California. The lake dries out and as it does so, the salt concentration in the remaining water increases so that halophilic archaea grow coloring the water pink.

Most organisms cannot live in such high salt environments because the salty water draws water out of their cells and effectively dehydrates them. The extremely halophilic archaea can survive because they contain an equally high amount of salt inside their cells, so the water is not drawn out. They have evolved cellular components that can tolerate this high concentration of salt inside their cells.

Don Juan Pond, VIctoria Land, Antarctica. The saltiest place on Earth with a salinity over 47% (seawater is 3.5% and the Dead Sea is 34%).

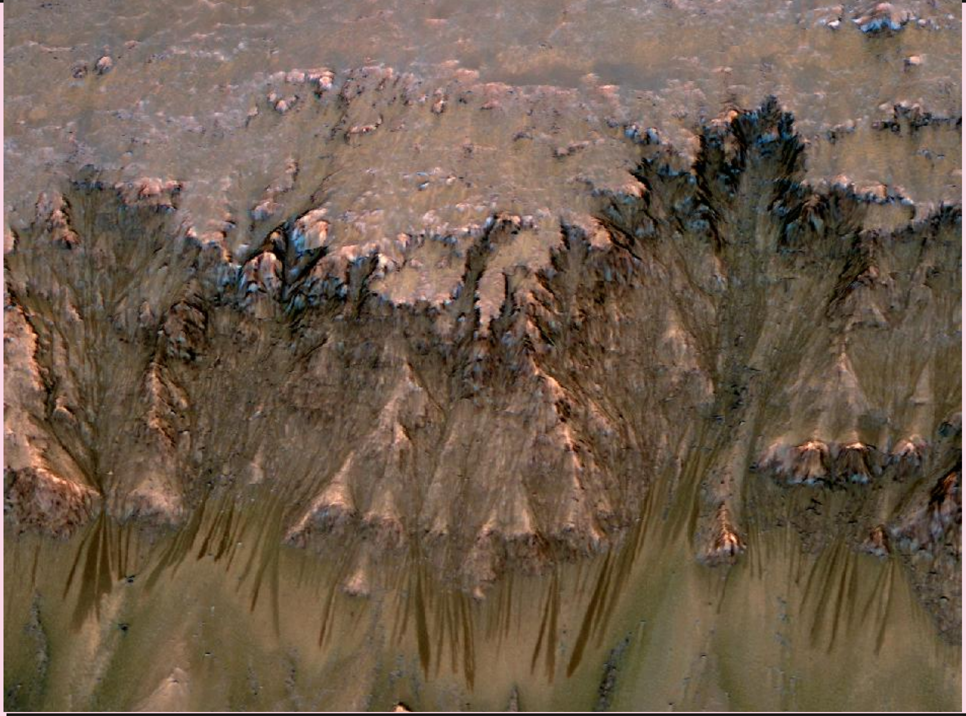
In the 1970s, scientists discovered another unique feature of some of the halophilic archaea. Like plants, these archaea can derive energy from light. However, the way they do it is very different than the way plants do. Instead of the many component proteins and pigments that plants use to harvest light energy, these halophiles use a single protein with one simple pigment. That pigment is a molecule called retinal, the same pigment in our eyes that detects light and allows us to see. This important discovery allowed scientists to study in great detail how retinal traps the energy of light.



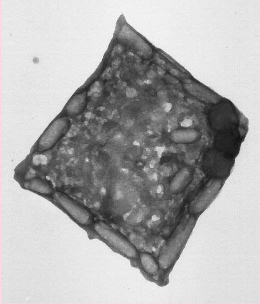
The retinal molecule changes shape when exposed to light, allowing the halophiles to trap the energy of sunlight to use to form new cells.

Gulf of Mexico brine pools. White salt deposits form on the yellow sediment as brine spills out of the pools.

Liquid water cannot exist on the surface of Mars today. The atmosphere is too thin and the surface is usually far below the freezing point of water. Even if the water were very salty, it would be frozen most of the time. In sun-lit places, liquid water might exist for brief periods, particularly just below the surface where it might run downhill as seen in crater such as Newton crater. Since the soils of Mars contain high amounts of salt, such water would be very salty.



Newton Crater on Mars showing streaks of apparent seasonal salty water flows.



Haloquadratum walsbyi, a square-shaped archaeon.

One kind of salt, perchlorate, is present in some Martian soils. This salt is very harmful to most Earth microbes, but the halophilic archaea are resistant to this salt. Some can even use perchlorate instead of oxygen to respire. Scientists have tried growing some of these halophiles under conditions like those that might exist on Mars and have found they can grow. So perhaps halophilic organs could have grown on Mars in the past when the planet appears to have had flowing water on its surface. Or perhaps even today, under the soil during the brief warm periods. Microbial life like this exists here on Earth in the cold, dry valleys of Antarctica and the high tops of the Andes mountains.

Don Juan Lake, Antarctica is 45% salt and may be similar to lakes on ancient Mars.

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https://hillierlake.com

Great Salt Lake, Utah
https://commons.wikimedia.org/wikiFile:Great_Salt_Lake_ISS_2003.jpg

Salt evaporation ponds, San Francisco, California
https://commons.wikimedia.org/
wikiFile:San_Francisco_Bay_Salt_ponds_2002.jpg

Owens Lake, California
https://commons.wikimedia.org/wikiFile:Owens_Lake,_California.JPG

Don Juan Pond, Antarctica
https://en.wikipedia.org/wiki/Don_Juan_Pond

Gulf of Mexico brine pool
https://www.flickr.com/photos/oceanexplorergov/38028083974

Craters brine pools
https://commons.wikimedia.orgwikiFile:NOAAseep_600CratersBrinePools.jpg

Square archaeal cell: Haloquadratum walsbyi
http://microbestiary.org/portfolio-item/haloquadratum-walsbyi/

Newton Crater on Mars
https://www.space.com/17048-water-on-mars.html

Don Juan Pond, Antarctica
https://www.astrobio.net/mars/salty-antarctic-pond-replica-mars-water/

On-line resources:

Halophiles, Microbewiki
https://microbewiki.kenyon.edu/index.php/Halophiles

Microbial Life in Hypersaline Environments
https://serc.carleton.edu/microbelife/extreme/hypersaline/index.html

Research review article:

H. Stan-Lotter and S. Fendrihan. Halophilic Archaea: Life with Desiccation, Radiation and Oligotrophy over Geological Times. Life (Basel). 5:1487-1496. 2015.