



# Going to Mars to Stay

*Our goal is the capacity for people to work and learn, and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity's reach in space -- we will strengthen America's leadership here on Earth."*

*- President Obama, April 2010*

## What does it mean to be Earth Independent?

### ➤ Resources

- Raw materials from soils and atmosphere
- Processes to convert them

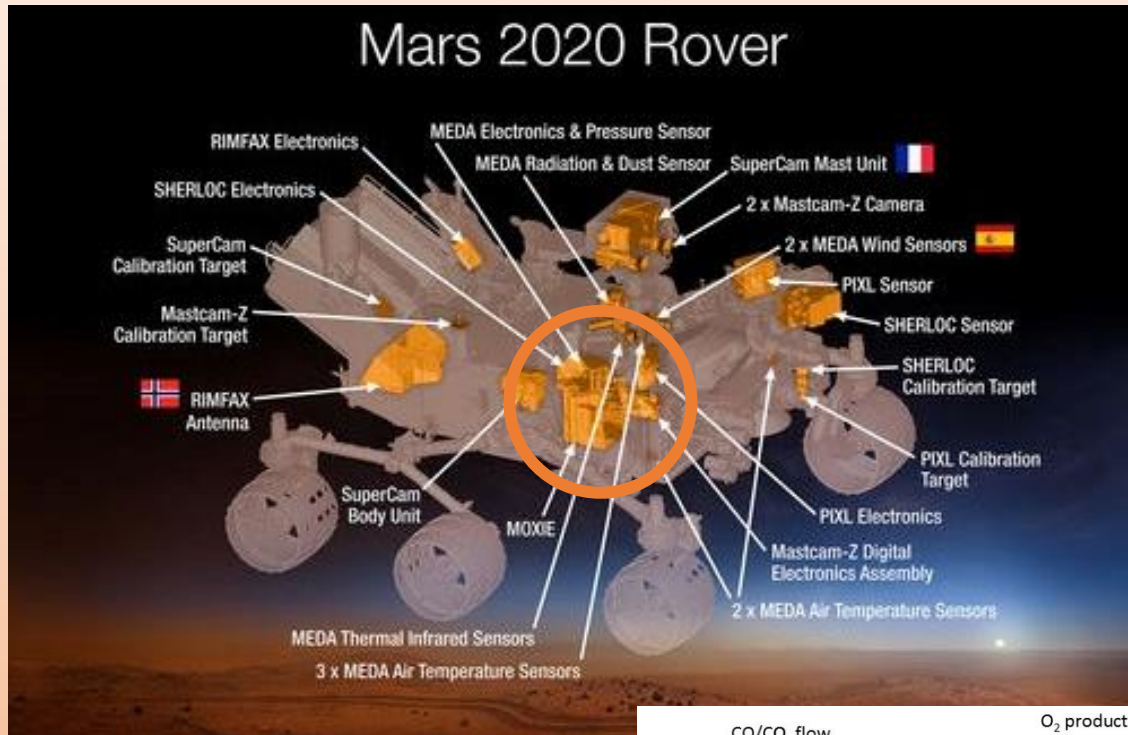
### ➤ Decision Making

- Ability to analyze and measure and provide data
- Flexible design to make changes and repairs
- Able to truly explore new worlds

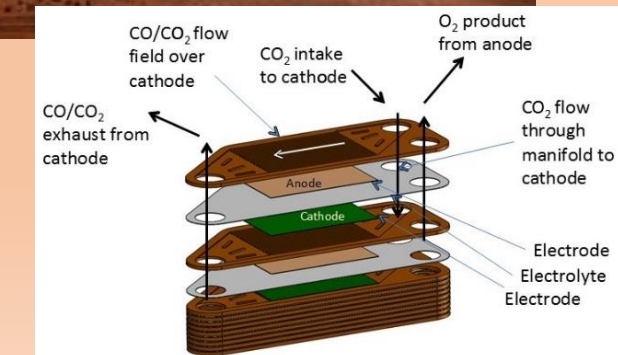
# Relying on Mars for Resources

Mars Atmosphere is 95% CO<sub>2</sub>

Mars surface holds water, and minerals like iron, silicon, or salts



**MOXIE (Mars Oxygen ISRU Experiment) will be first on-Mars production of O<sub>2</sub> from Mars CO<sub>2</sub> atmosphere to demonstrate In-Situ Resource Utilization (ISRU)**



Solid Oxide Electrolyzer SOXE (Hecht et al, 2015)

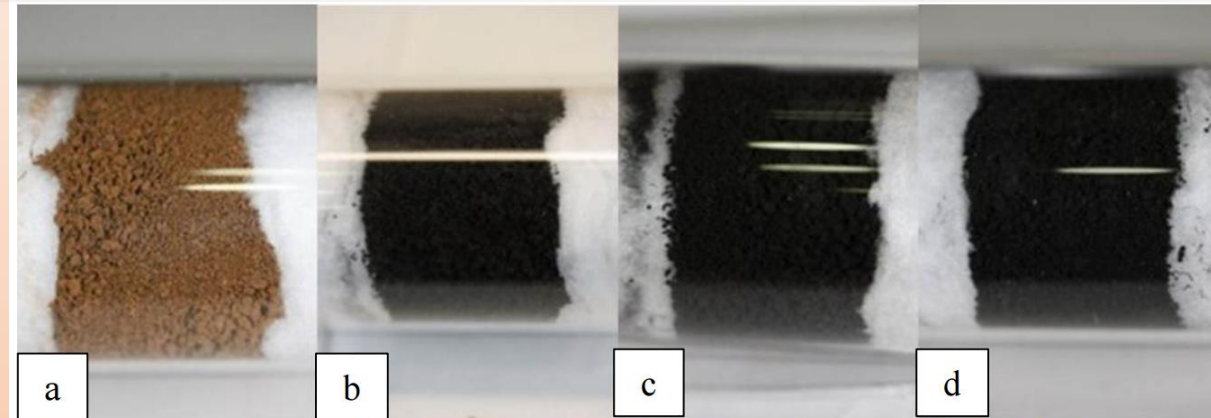
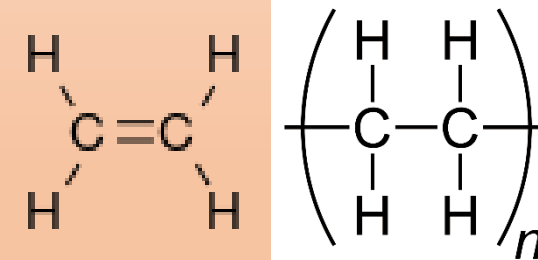


Figure 10. Martian regolith simulant. *Pre-carbon formation (a) and after 1hr(b), 4hrs (c), and 16hrs(d) of carbon accumulation.* (Abney et al, 44th Int'l Conf on Environmental Sys)



Figure 14. Polyethylene-bound regolith simulant bricks. (Abney et al, 2014)



Ethylene & Polyethylene Monomer

Many organic molecules could be made with Mars atmosphere CO<sub>2</sub> and surface H<sub>2</sub>O

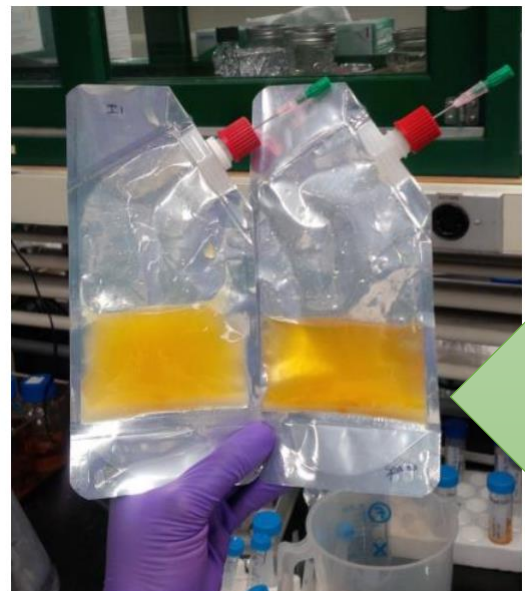
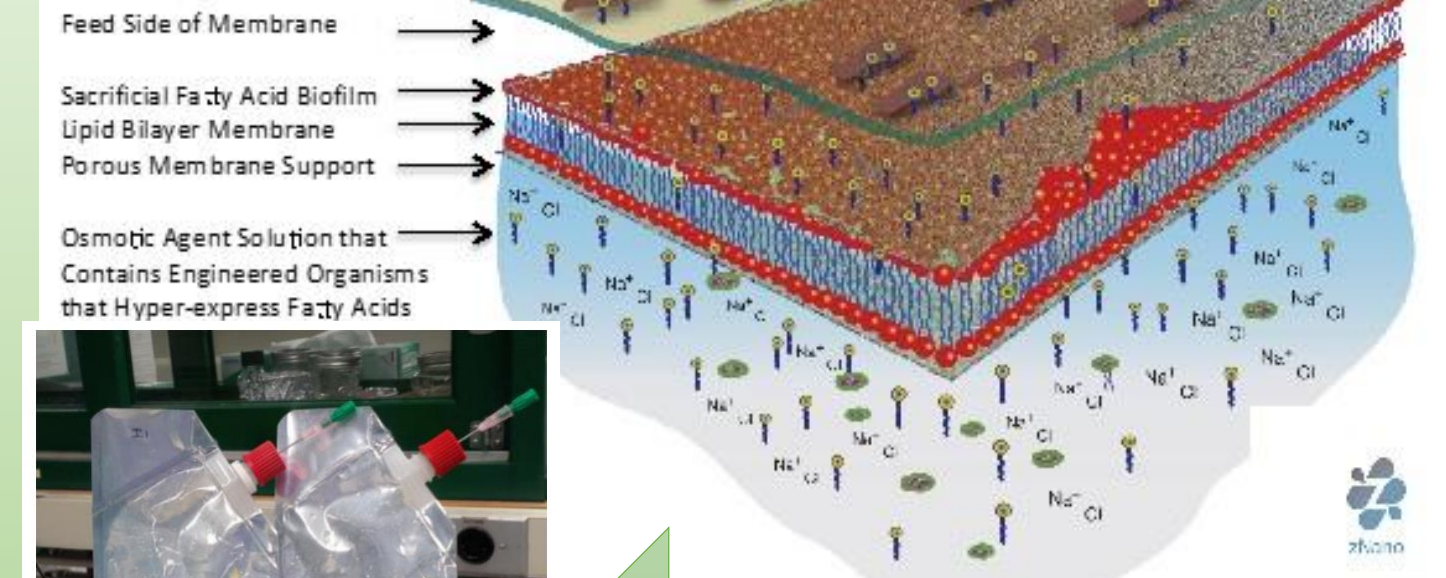
# Using & Understanding Biological Systems

Sensor technology required to understand our microbiome and know what to do with the information – no sample return to Earth!

Apply Synthetic Biology to create what we need to sustain human life, and our equipment and systems



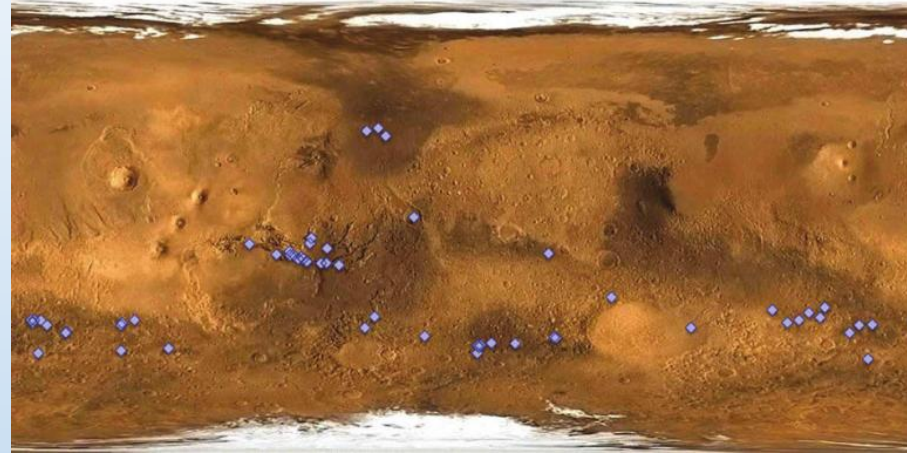
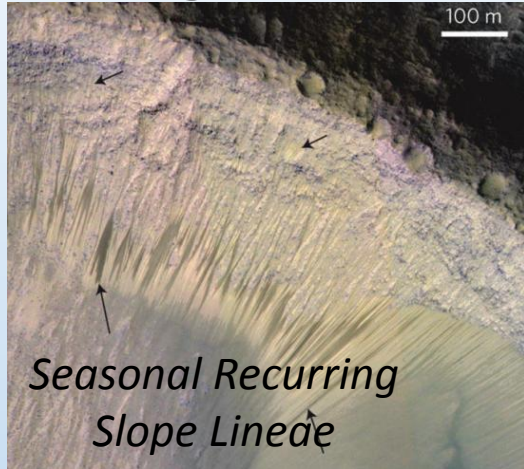
## Synthetic Biological Membrane for Wastewater Recovery



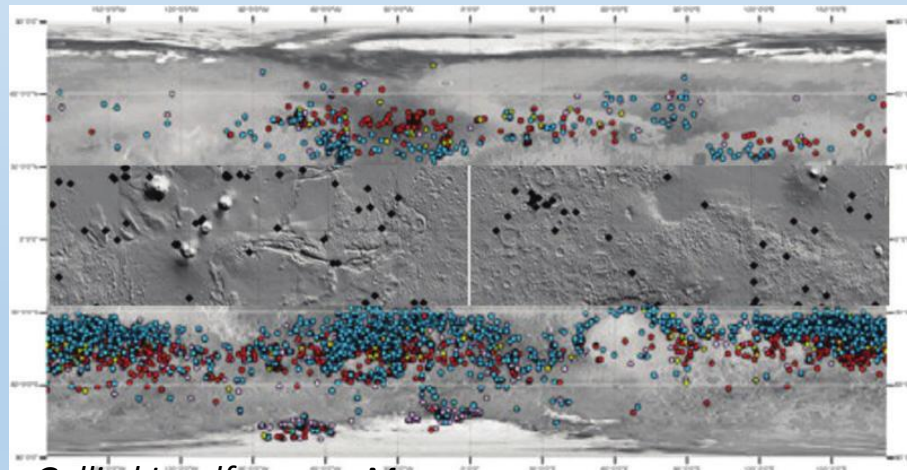
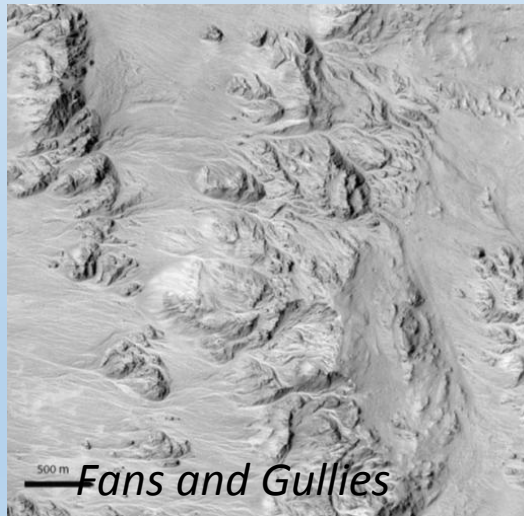
Experiments to supply nutrients on demand from engineered spores and vegetative cells (Williams 2015)

# Protecting Research – Mars Special Regions

“a region within which terrestrial organisms are likely to replicate”



Confirmed Recurring Slope Lineae on Mars



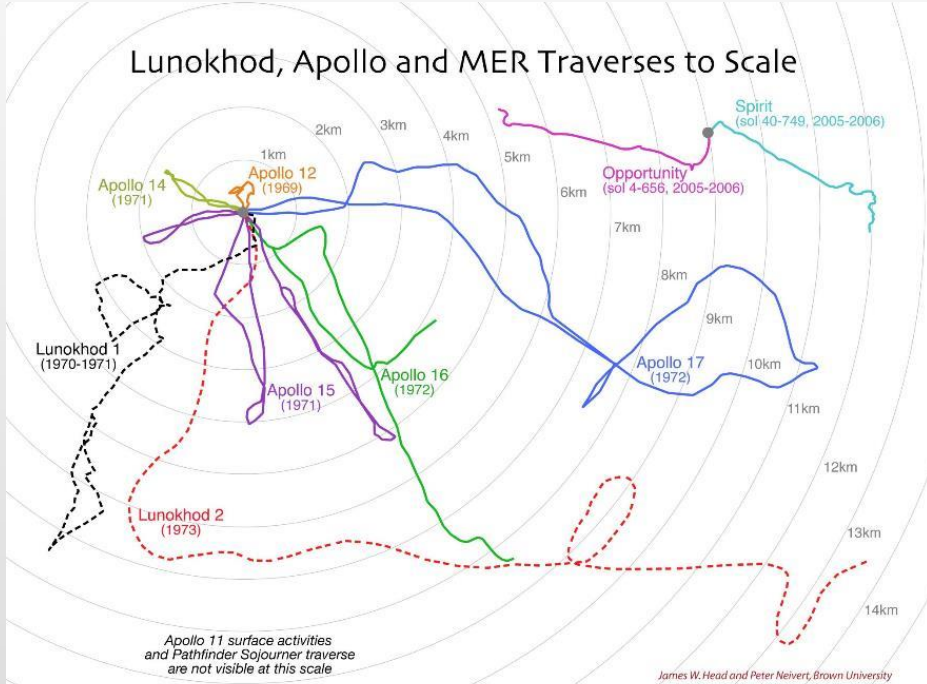
Gullied Landforms on Mars



Ground Ice in Phoenix Lander trench

- For  $-25^{\circ}\text{C}$  and above & Water activity threshold of 0.5 - Developing knowledge of Earth's chemolithoautotrophic life and effect of chaotropes
- Predictions of natural conditions over the next 500 years on Mars or Spacecraft (*or ISRU system!*) induced special regions

# Protecting Our Explorers



Prototype EVA Gloves with Flexible Aerogel



Z-Suit Prototype enabling kneeling postures

After 3,042 days on Mars, Opportunity Rover had driven 21.4 miles  
 After 3 days on the Moon, Apollo 17 had driven 21.6 miles (Ross and Eppler 2015)

## EVA Increase for Human Mars Exploration

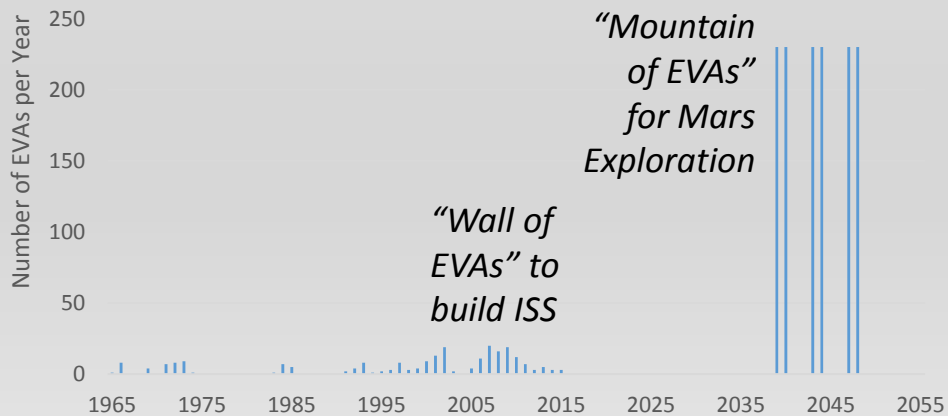


Figure 14-8. Fingernail and shoulder trauma sustained during EVA training (Jones et al., 2006).