

Space Technology

Game Changing Development

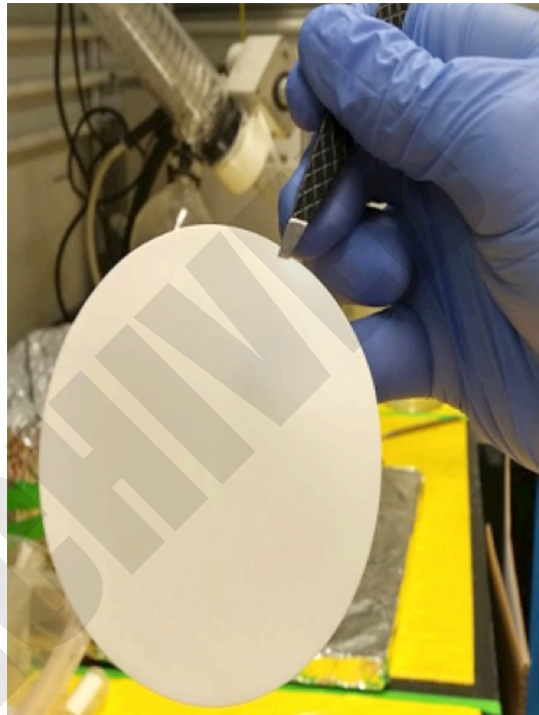
Synthetic Biological Membrane

Membranes are a vital component of many biological processes. Due to their low mass and power requirements, membranes are also used extensively in modern spacecraft. Membranes are traditionally used for diverse applications such as spacesuits, chemical separations, sensors and structural components such as vapor barriers. Conventional man-made polymer membranes are relatively fragile and have short life spans because they are susceptible to chemical, physical, biological and radiation-induced damage. For long duration space missions, this would require an increase in resupply, mass, and crew time (maintenance for repairs and replacement). Conversely, biological membranes, such as those that make up human skin, intestines and other organs, are extremely reliable and have lifespans that exceed 70 years.

Recently, NASA developed a new generation of forward osmosis (FO) membranes, which mimic naturally occurring biological membranes. These membranes have been engineered to purify spacecraft wastewater and have been shown experimentally to be able to regenerate themselves. However, these existing lipid membranes require human intervention to remove them from service and complete repair procedures.

What is forward osmosis?

Forward osmosis is a process wherein two fluids of different solute concentrations are separated by a semipermeable membrane. The vapor pressure difference between the two solutions results in an osmotic potential. The osmotic potential is the driving force for water transport across the membrane. The membrane allows the solvent to pass through its pores, but not the solute.



Forward osmosis membrane developed by NASA.

The flux of solvent across the membrane continues until the osmotic potential across the membrane is equalized and the solute/solvent concentration is in equilibrium. In wastewater treatment applications where the solvent is water and the solutes are the contaminants, the semipermeable membrane is designed to maximize the flux of water through the membrane and not the contaminants.

The goal of this project is to use synthetic biology techniques to develop biomimetic FO membranes that can self-repair when exposed to chemical and physical damage, as well as radiation and fouling. The self-repair capability is derived from the regenerative characteristics of living systems. Ultimately, this living membrane will be used to extend the operating life and improve the performance of

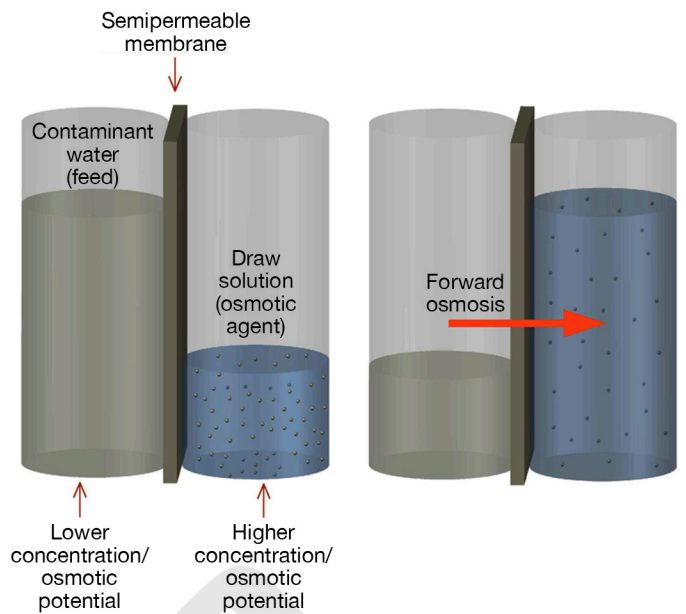
NASAfacts

membrane-based life support systems currently being used by NASA.

Biological membranes are primarily composed of lipid bilayers. Lipids are organic compounds that, due to their polar hydrophobic fatty acid tails per lipid molecule, are able to self-assemble spontaneously. The lipid bilayer acts as a selective barrier, letting only specific molecules cross the membrane. Recent research into membranes for Next Generation Life Support applications has identified a type of FO membrane that can function as a biomimetic structure.

Synthetic biology techniques will be used to genetically engineer organisms that will hyper-express organic molecules that compose the membrane. As shown below, the genetically engineered organisms are grown in the osmotic agent solution where they continuously produce organic molecules. The organic molecules permeate the membrane from the osmotic agent solution into the feed side. On the feed side, the membrane builds up until shear forces caused by the circulation of the feed cause it to shed off. This process along with continuous replacement provides a cleaning for the surface of the membrane and a mechanism for biological regeneration of damage.

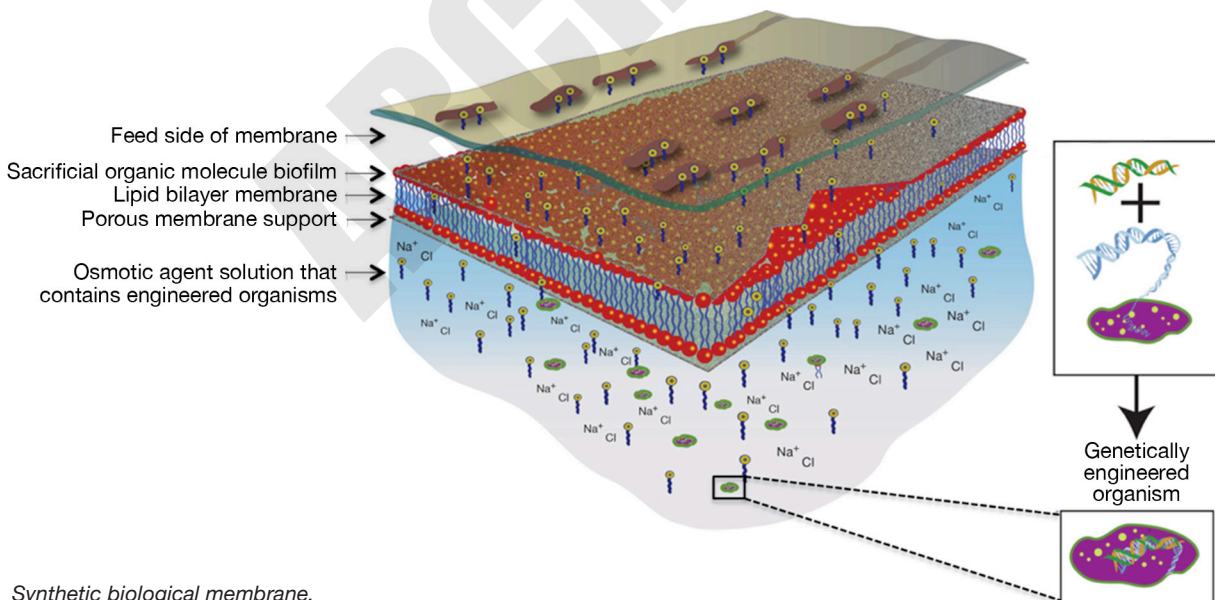
The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space



Water flows through the membrane from the wastewater (contaminant) side to the clean side leaving the contaminants behind.

endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit <http://gameon.nasa.gov/>



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