Water Recycling Technologies: Forward osmosis seminar

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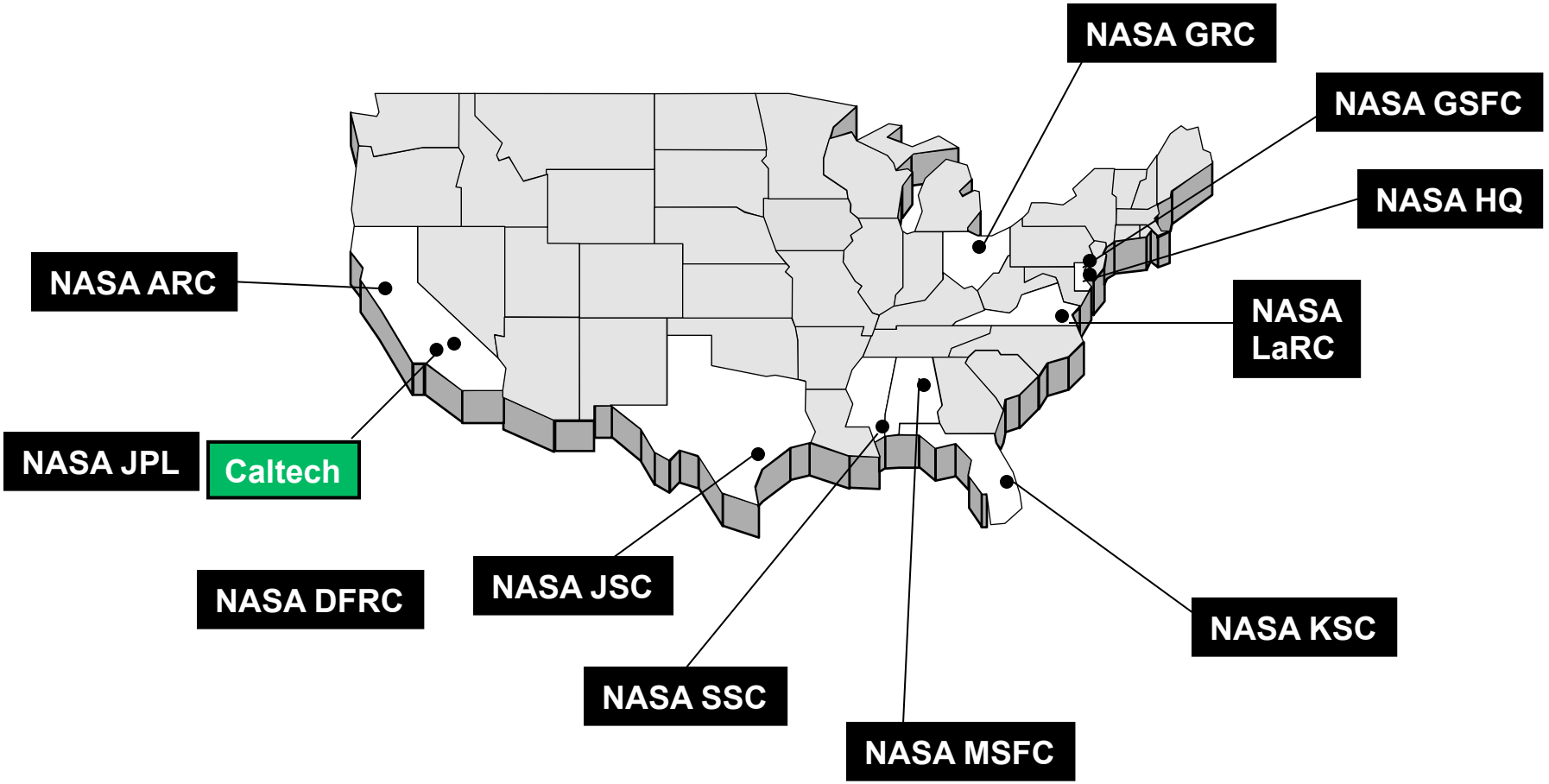
NASA facilities



National Aeronautics and Space Administration

Ames

Discovery Innovations Solutions

NASA Ames Research Center (ARC)

- One of ten NASA field centers
- Located in the heart of California's Silicon Valley
- For more than 76"years, Ames has led NASA in conducting world-class research and development in aeronautics, exploration technology and science aligned with the center's core capabilities
- **Established:** December 20, 1939, as part of the National Advisory Committee for Aeronautics (NACA), in 1958 absorbed into the National Aeronautics and Space Administration (NASA)

Earth’s natural life support system provides the air we breathe, the water we drink and other conditions that support life.#

…to live in space, these functions must be done by artificial mean.

Advanced Life Support (AS)

1. Air revitalization
2. **Water recycling**
3. Solid waste
4. Power production
5. Extravehicular activity (EVA)

OBJECTIVE → TO KEEP ASTRONAUTS ALIVE

International Space Station (ISS)

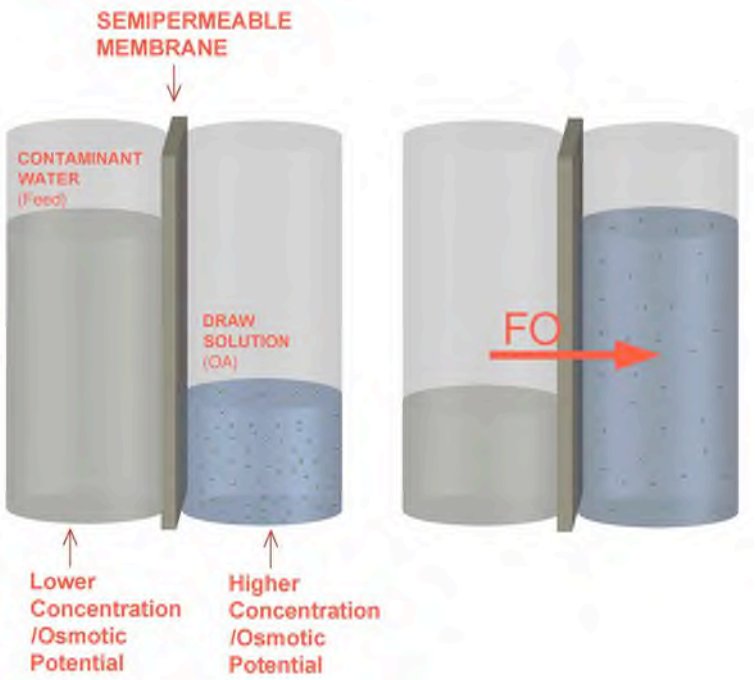
Would he have been able to reach the New World without water?

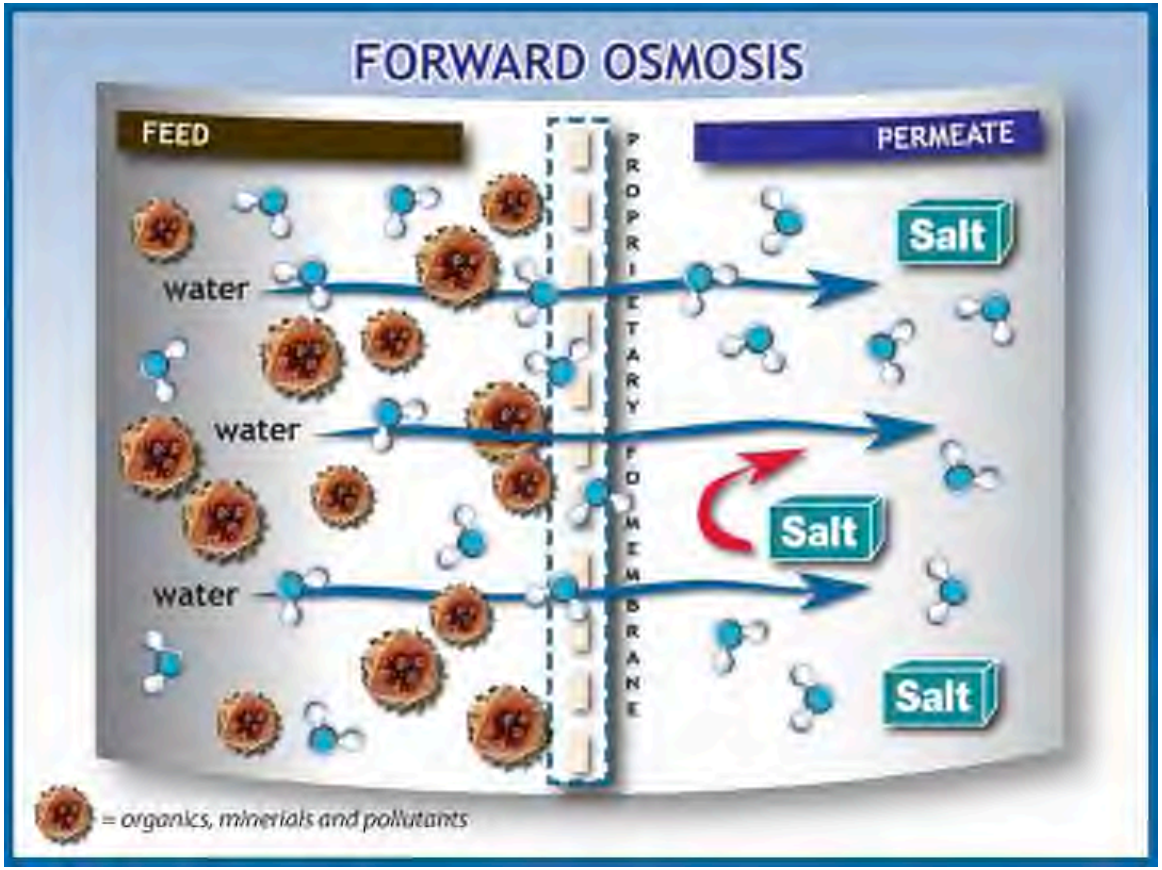
PROBABLY NOT

NASA Forward Osmosis Research and development

- **NASA has been actively researching FO since 1993.**
- **FO has been selected by NASA as part of the baseline system for the Next Generation Life Support Mars base water recycling system.**
- **NASA has also developed a wide range of FO products for both space and terrestrial applications.**
- **Most of this work has been published in the International Conference on Environmental Systems.**

Forward osmosis




FORWARD OSMOSIS
FEED
PERMEATE
PROPRIETARY FO MEMBRANE
water
water
water
Salt
Salt
Salt
= organics, minerals and pollutants

Direct Osmotic Concentration System (DOC)

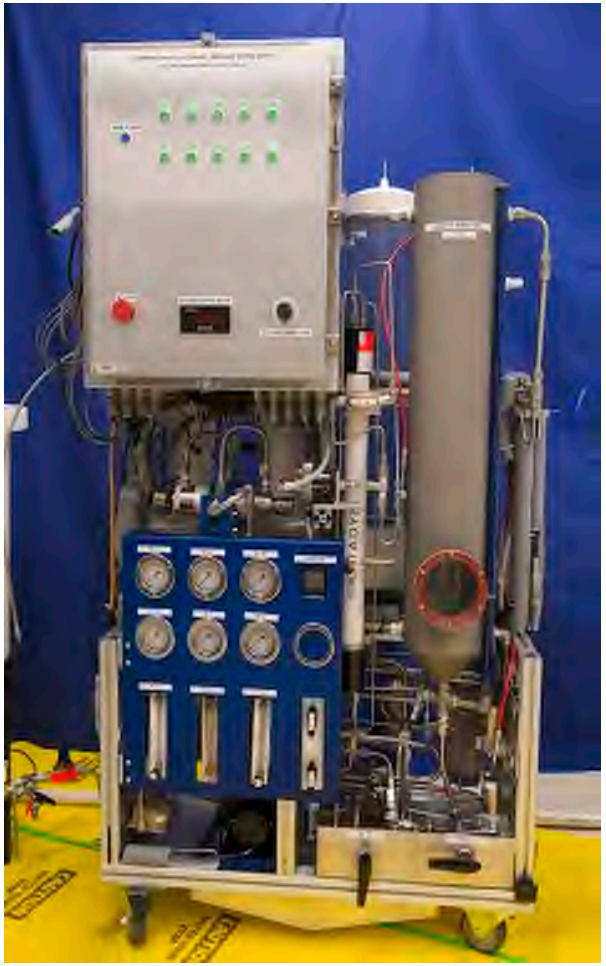
- The DOC process uses FO followed by RO to treat hygiene wastewater.
- Urine and humidity condensate are treated using a direct contact membrane distillation (DCMD).
- The product of FO, RO and DCMD are post treated using an Aqueous Phase Catalytic Oxidizer (APCO).

Lightweight Contingency Water Recycling System (LWC)

- The LWC system is an individual (personal) urine recycling system.
- It is designed for EVA and emergency contingency applications.
- The LWC uses activated carbon treatment followed by forward osmosis (FO).
- It produces a hydration and electrolyte fluid (fortified drink/food product) for crew consumption.

Forward Osmosis Secondary Treatment (FOST)#

- FOST was designed to treat the effluent of a membrane aerated bio-Reactor (MBAR).
- The feed to MBAR was urine, humidity condensate, and gray water.
- The FOST system functions as a post treatment step to the bioreactor.
- The FOST removes dissolved solids, ammonia, and suspended solids.
- It also provides a physical barrier to microbial and viral contamination.



Forward Osmosis Bag (FOB) Flight Experiment

- In 2011 NASA conducted an FOB flight test on the Space Shuttle (STS 135).
- FOB was a water purification device for the recovery of a potable drink from wastewater in microgravity (like the LWC)
- The objective of the experiment was to verify that forward osmosis works in microgravity and evaluate the effects of micro-scale buoyancy driven mixing.
- Flux rate and salt rejection were determined at 6- and 24-hour intervals.

The results of this flight experiment demonstrated that the FO process works in microgravity, salt rejections were the same as in 1 g but flux rates are reduced.

Cargo Transfer Bag (CTB)

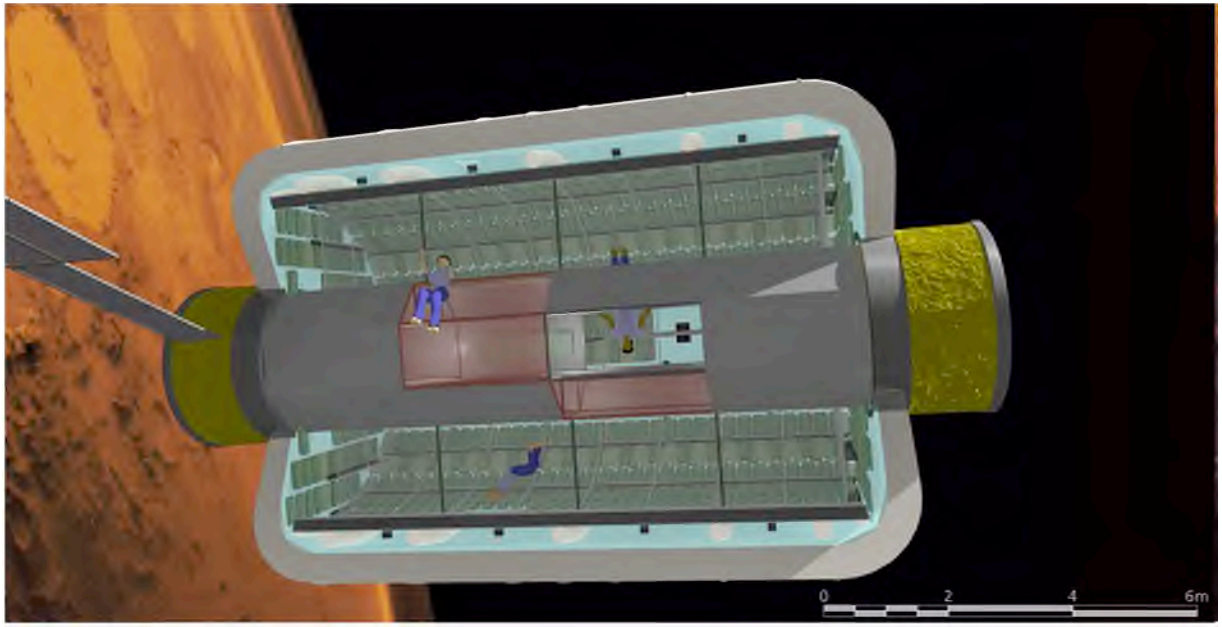
- CTB is an embedded forward osmosis membrane water treatment element inside of a cargo transfer bag.
- CTBs are cloth bags used to deliver cargo to orbit in the current international human space flight logistics system; they are a standardized expendable logistics item.
- Using the CTB as a platform allows the FO water treatment elements to be embedded in and piggybacked on cargo being delivered to the ISS.
- CTBs are used for emergency backup water treatment and radiation shielding.

Water Walls (WW)#

- The WW concept proposed a system for structural FO elements that provides thermal, radiation, water, solids and air treatment functions.
- The approach allows life support functions to be removed from the usable habitat volume and placed in the walls of the space craft by way of a radiation shielding water wall.

- WW provides the following life support function
  - Gray water and urine processing for potable water
  - Black water processing for solid waste
  - Air processing for CO_2 removal and O_2 revitalization
  - Air processing for volatile organic removal
  - Thermal and humidity control
  - Radiation protection
  - Insitu generation of construction materials

Water Walls (WW)#



STANDARD W.W. BAG UNIT
POLYETHYLENE BAG WITH ONE OR MORE SPECIALIZED MEMBRANES

BAG: 25 CM x 50 CM
POUCH: 22.5 CM x 45 CM

INDIVIDUAL W.W. BAGS ARRAYED IN POCKETED MESH PANEL
MESH ALLOWS AIR + LIGHT TO REACH BAGS

IN/OUT PORTS W/TUBES

SEWN SEAM SEPARATING POCKETS

W.W. BAGS SECURED IN INDIVIDUAL MESH POCKET AFFIXED TO OPEN MESH BACK PANEL

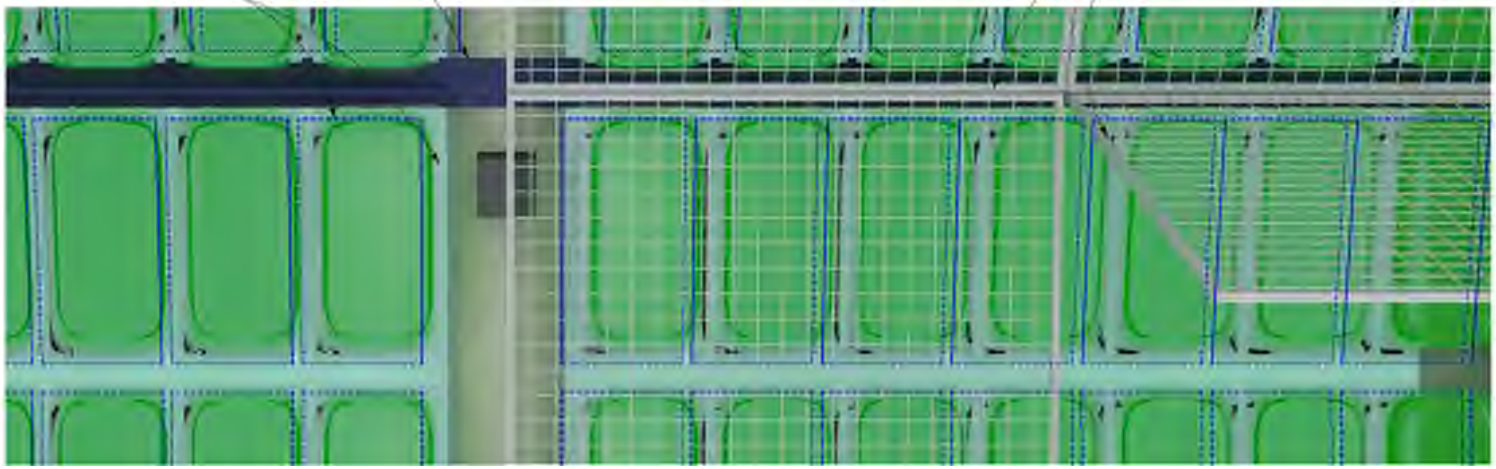
SNAPPED CLOSURES AT TOP AND BOTTOM OF EACH POCKET FOR SECURE ACCESS

T-BEAMS SPAN BETWEEN INNER CURVATURE OF RIGIDIZED HOOP STRUCTURE. T-BEAM FLANGES ABUT, WHILE STANDOFF WEB IS INTERRUPTED FOR TUBE AND LIGHTING RACEWAY

FRONT AND BACK LAYERS OF ARRAYED BAGS OFFSET TO PROVIDE OVERLAP AT EDGES + PROVIDE CONTINUOUS RADIATION PROTECTION

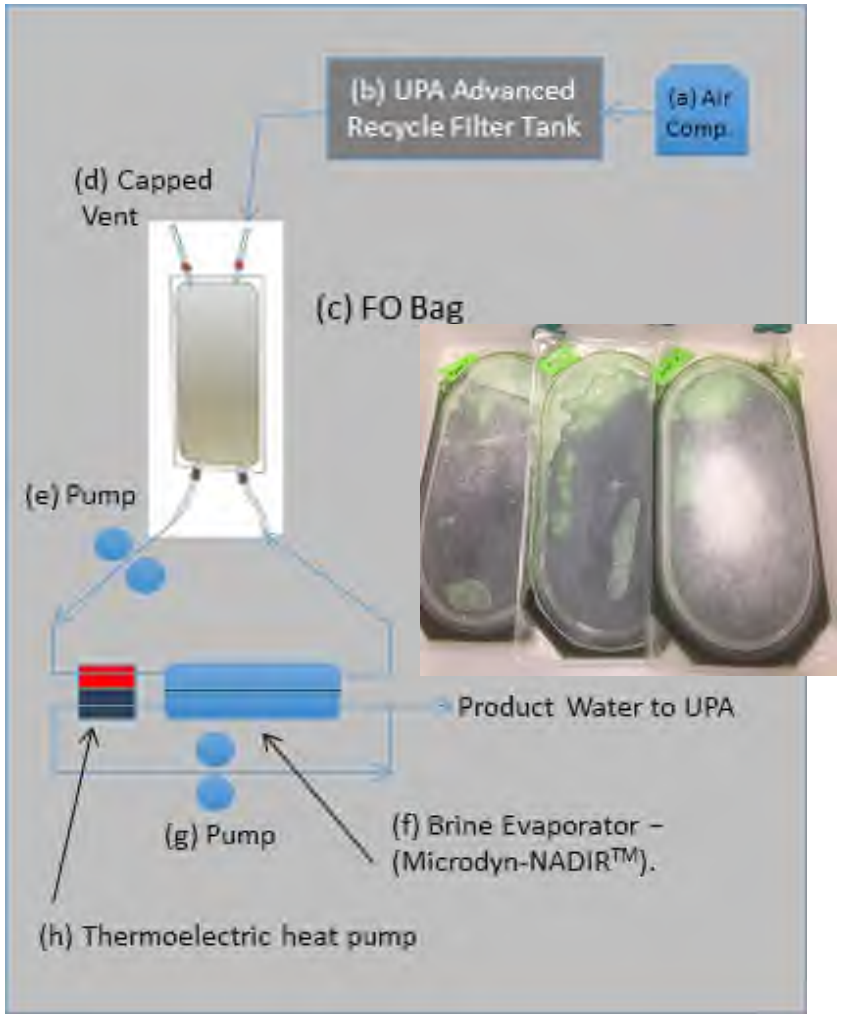
WATER WALLS BAG INSTALLATION

HARD OPEN-GRID PANELS PROTECT ARRAY OF W.W. BAGS. PANEL HINGED AT T-BEAM STANDOFF WEB FOR ACCESS



Forward Osmosis Brine Drying (FOBD)#

- The FOBD system is composed of two main elements: the FO bag and the OA regeneration system.
- The first element is the FO bag, which is separated into two compartments by a membrane that allows water to pass through it.
- The second element is the OA regeneration system, which removes the product water from the OA and re-concentrates the OA.



Personal Water Reclamation SysteM (PWRS)

- PWRS is derived from the LWC
- PWRS uses pervaporation membranes and no pretreatment carbon bed.
- Like the LWC, the PWRS is intended for personal urine recycling and water recovery during water emergencies.
- Currently being designed for use in Solar Impulse aircraft.

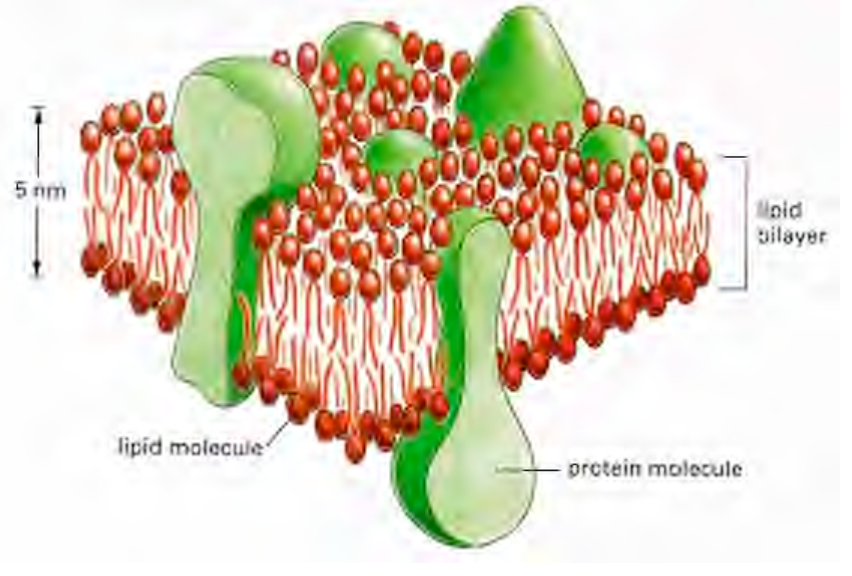
- Sustainability Base building at NASA-ARC
- Gray water from sinks and showers → flush water for toilets and urinals
- Forward osmosis (FO) & Reverse osmosis (RO) technique

Army/NASA Forward Operating Base Water Recycling System

Technology based on the design of the Green Building system

<u>General Specifications</u>
Capacity: 4500 gallons per day
Volume: Maximum 416 cubic feet and fits within a Tricon shipping container
Weight: Maximum 7110 pounds
Recovery Rate: Minimum 75%
Disinfection: Chlorine
Energy Use: Less than 20 Watt-hr per gallon

Advanced Membranes

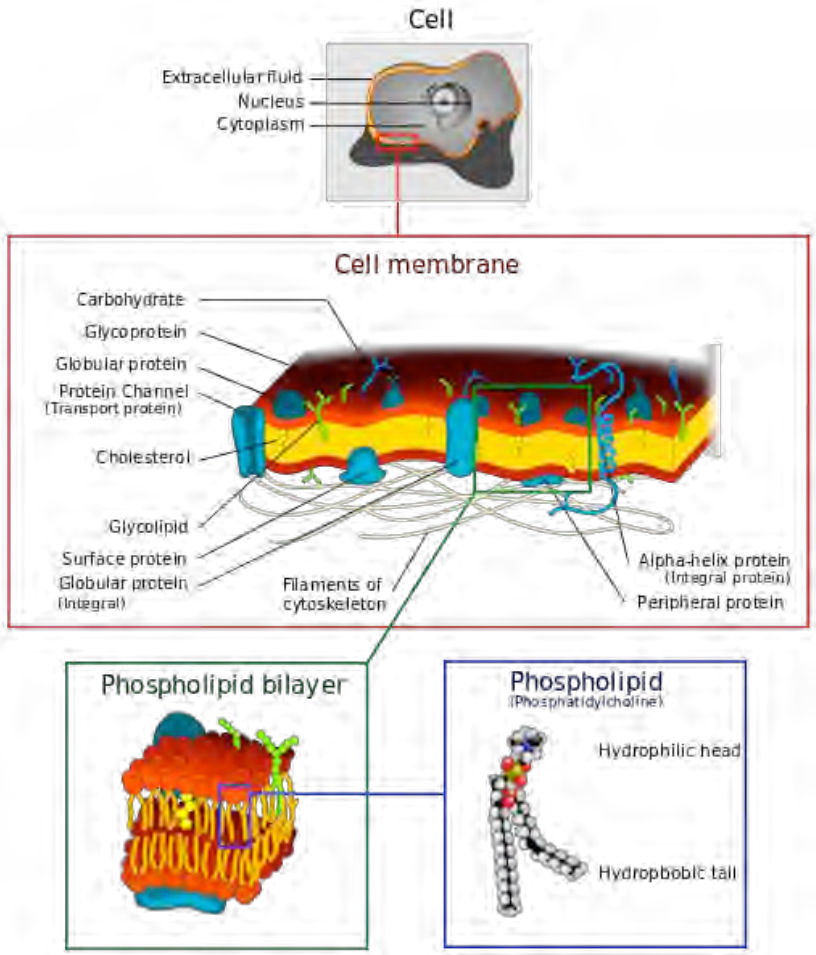


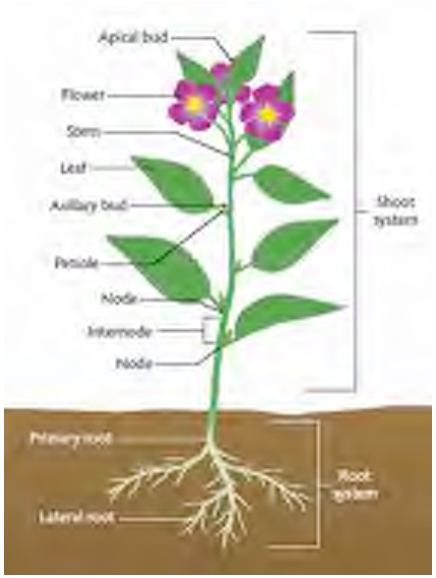
Lipid Bilayer Membranes

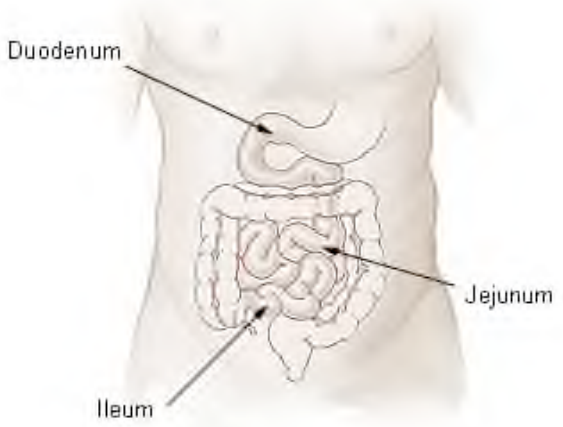
Aquaporin Embedded Protein Membranes

Glass Membranes, Nano-tube Membranes, Osmotic Solids, and Novel Backings

Lipid Membranes







SBM: Synthetic Biological Membrane

OBJECTIVE: to develop a Synthetic Biological Membrane (SBM) for wastewater treatment applications. The SBM is an integration of genetically engineered organisms and physicochemical substrates to produce a new "living" material with expanded reliability derived from the regenerative capabilities of biological structures such as the human intestine.