



# NASA Ames Water Recycling Technology Development

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# Advanced Life Support



## Objective:

Keep Astronaut alive

Provide habitable environment

Reduce Cost



# International Space Station



# Mars





## Inputs

Water

Oxygen

Waste  
Collection

Temperature  
Control

Pressurized  
Environment

Energy

## Outputs

Waste  
Water

Carbon  
Dioxide

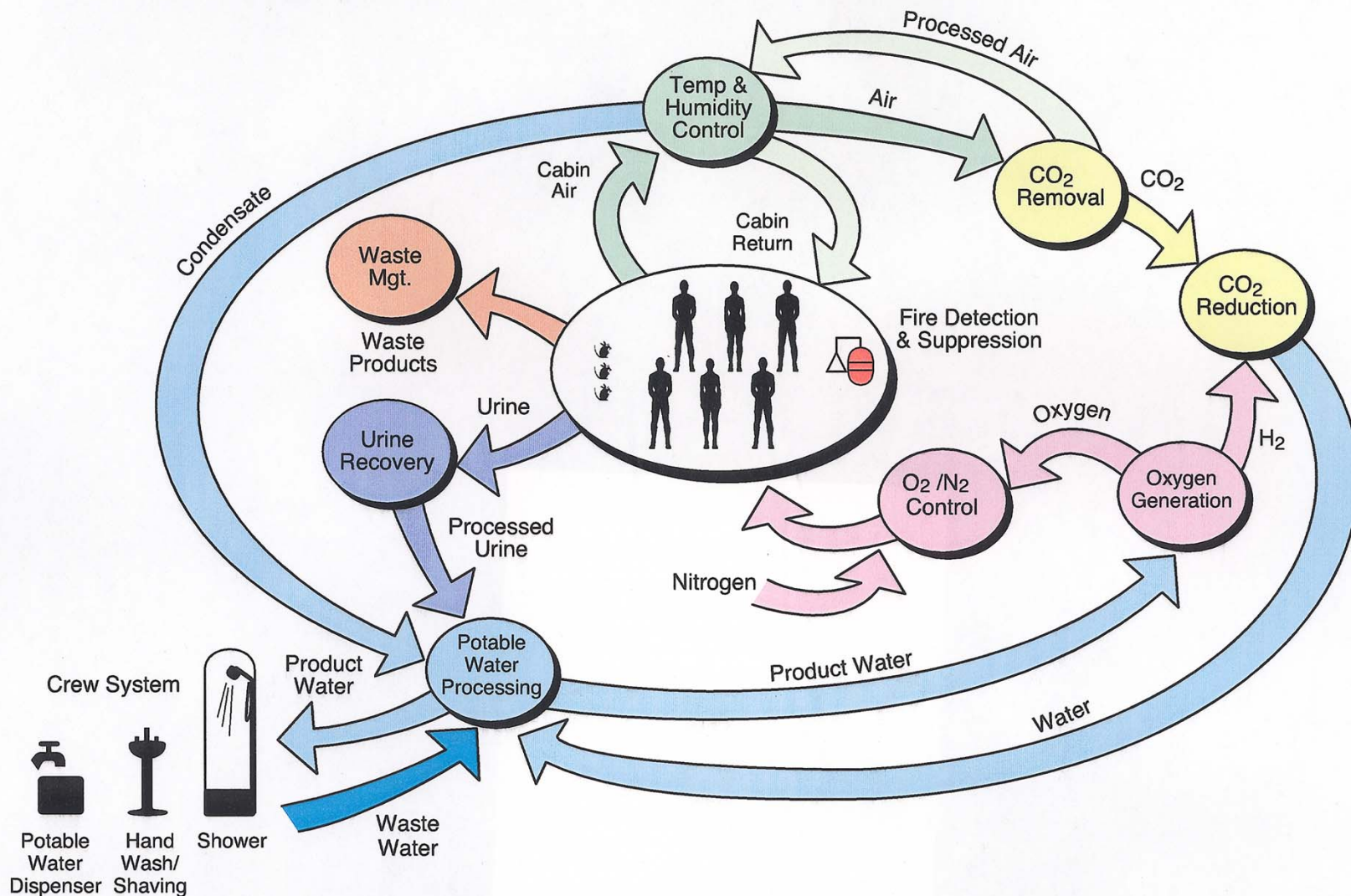
Volatile  
Organics

Solid  
Wastes

Heat



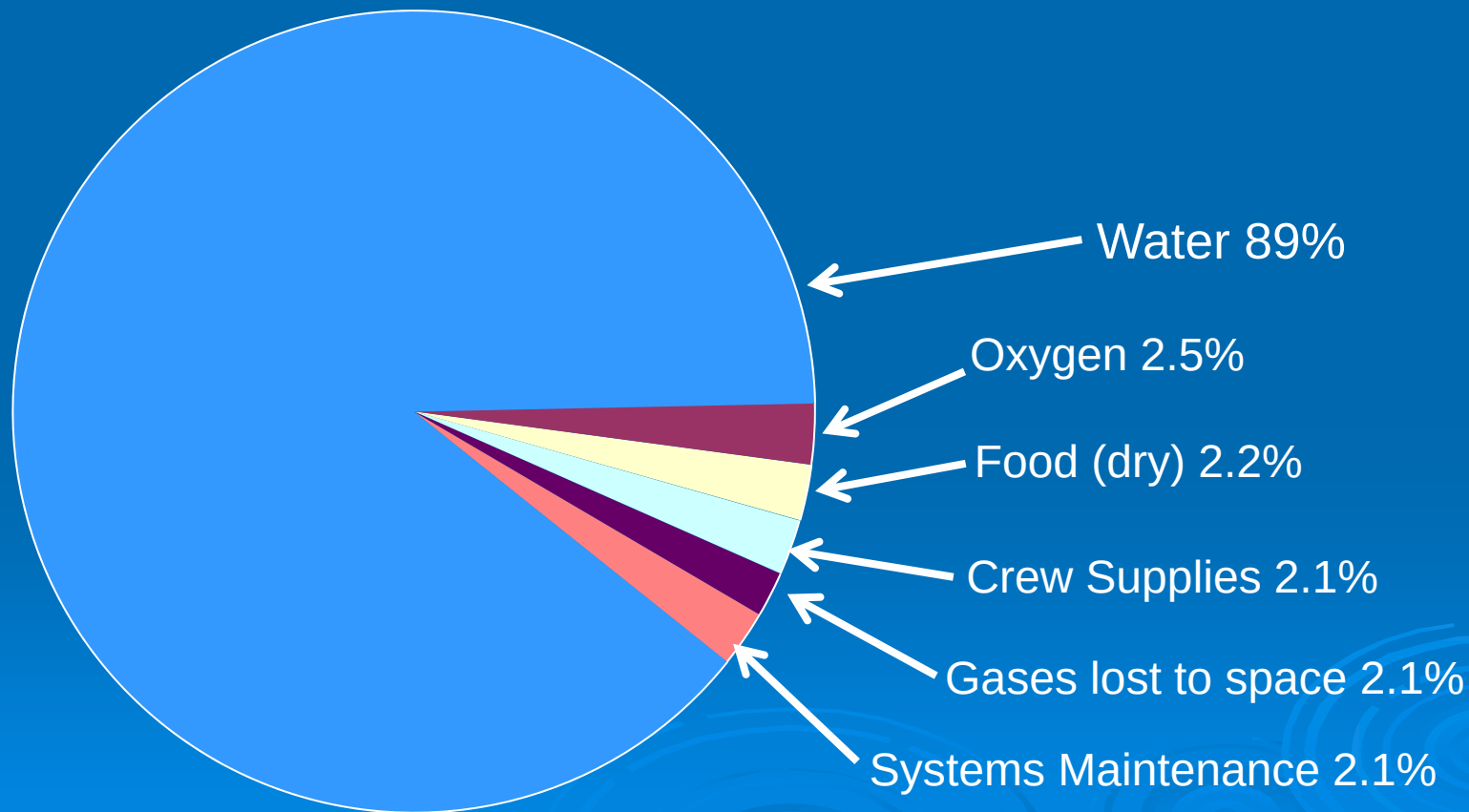
# Space Station Regenerative ECLSS Flow Diagram (Baseline and Scarring)





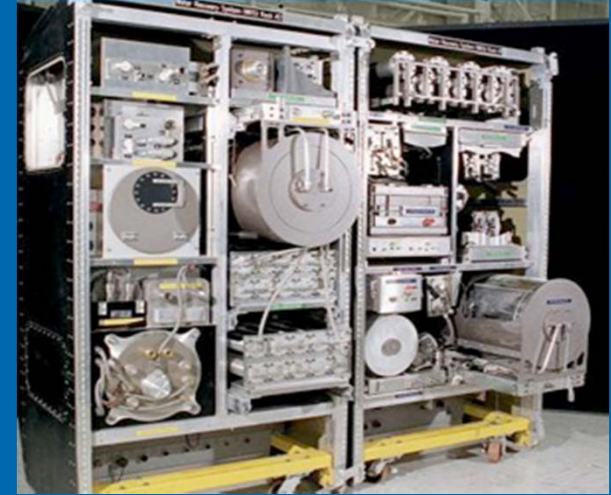
# Life Support Requirements

Open-loop life support system re-supply mass



# ISS US Water Processing Assembly

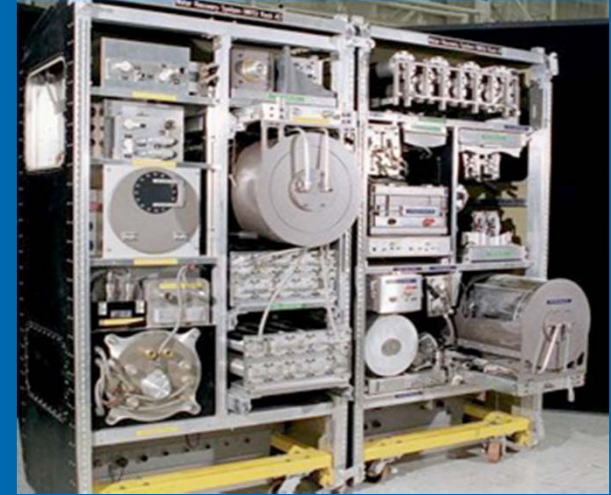
- Wastewater is recycled using distillation, adsorption, and oxidation.
- Urine, hygiene, and condensate are recycled to drinking water.





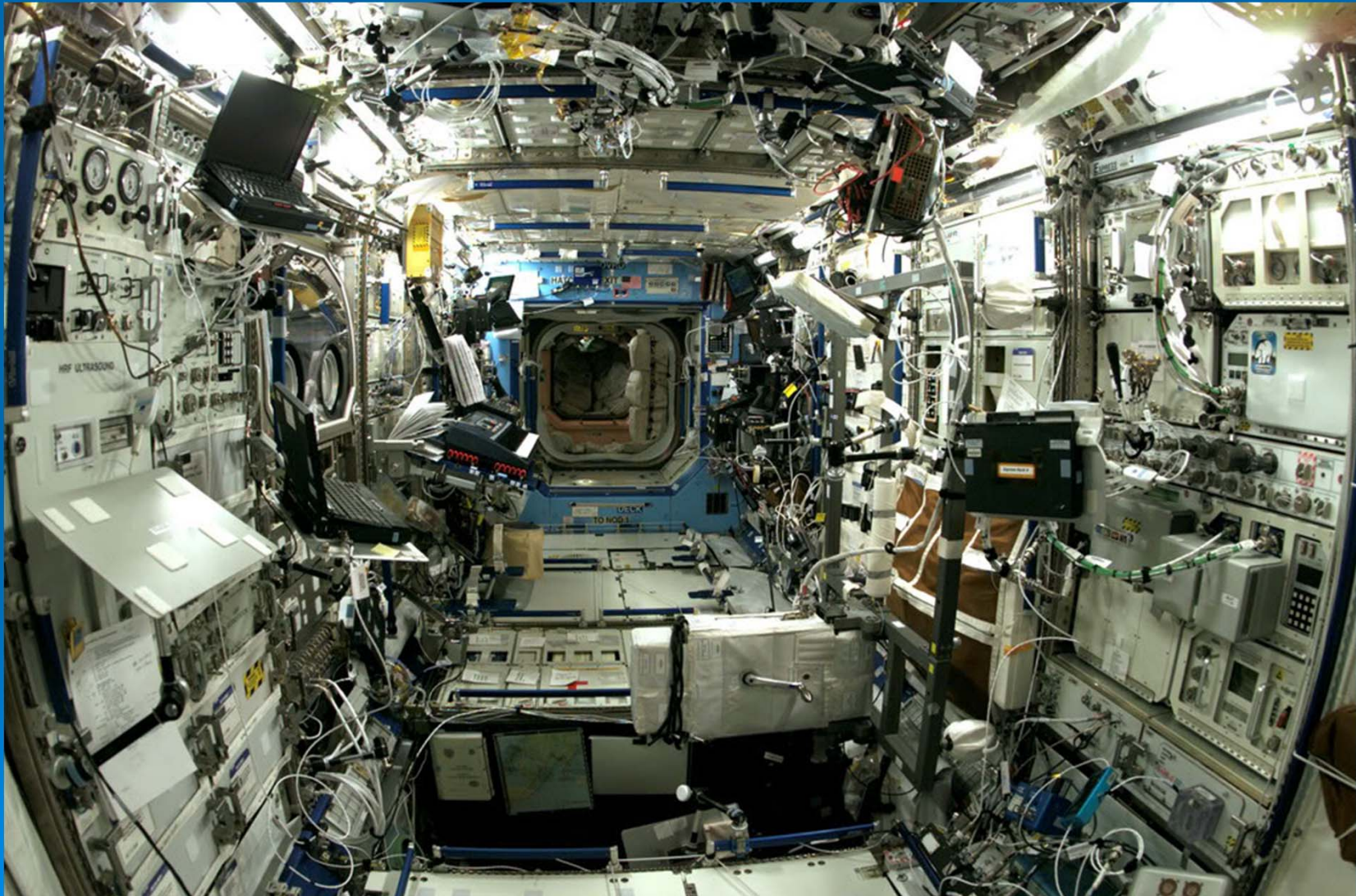
# ISS US Water Processing Assembly

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# Concept to Practice

It is one thing to talk about what could be done but entirely another to make it work

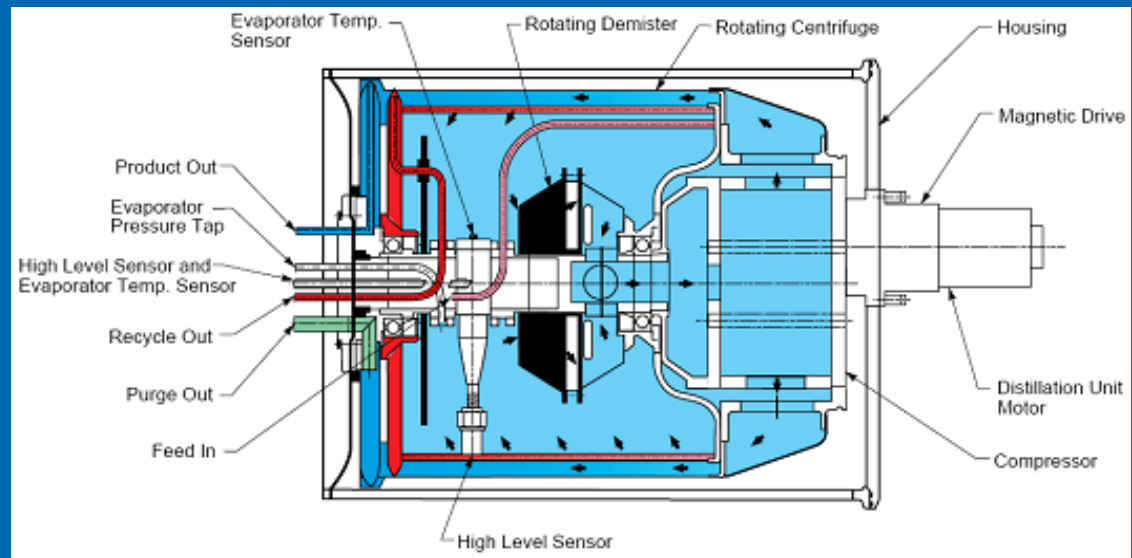




# ISS Urine Processing Assembly

Based on vapor  
compression distillation

Susceptible to calcium  
scaling

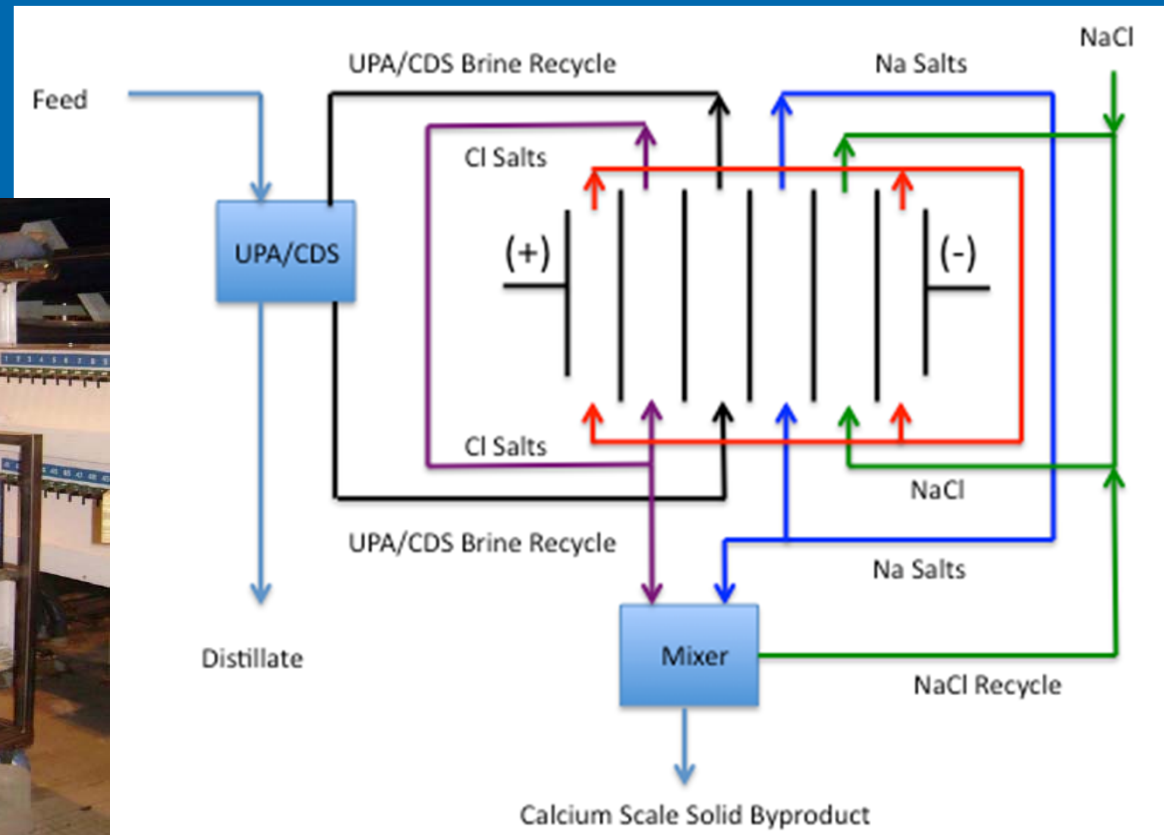


Two types of calcium  
sulfate scale

# Electrodialysis Metathesis



EDM test stand

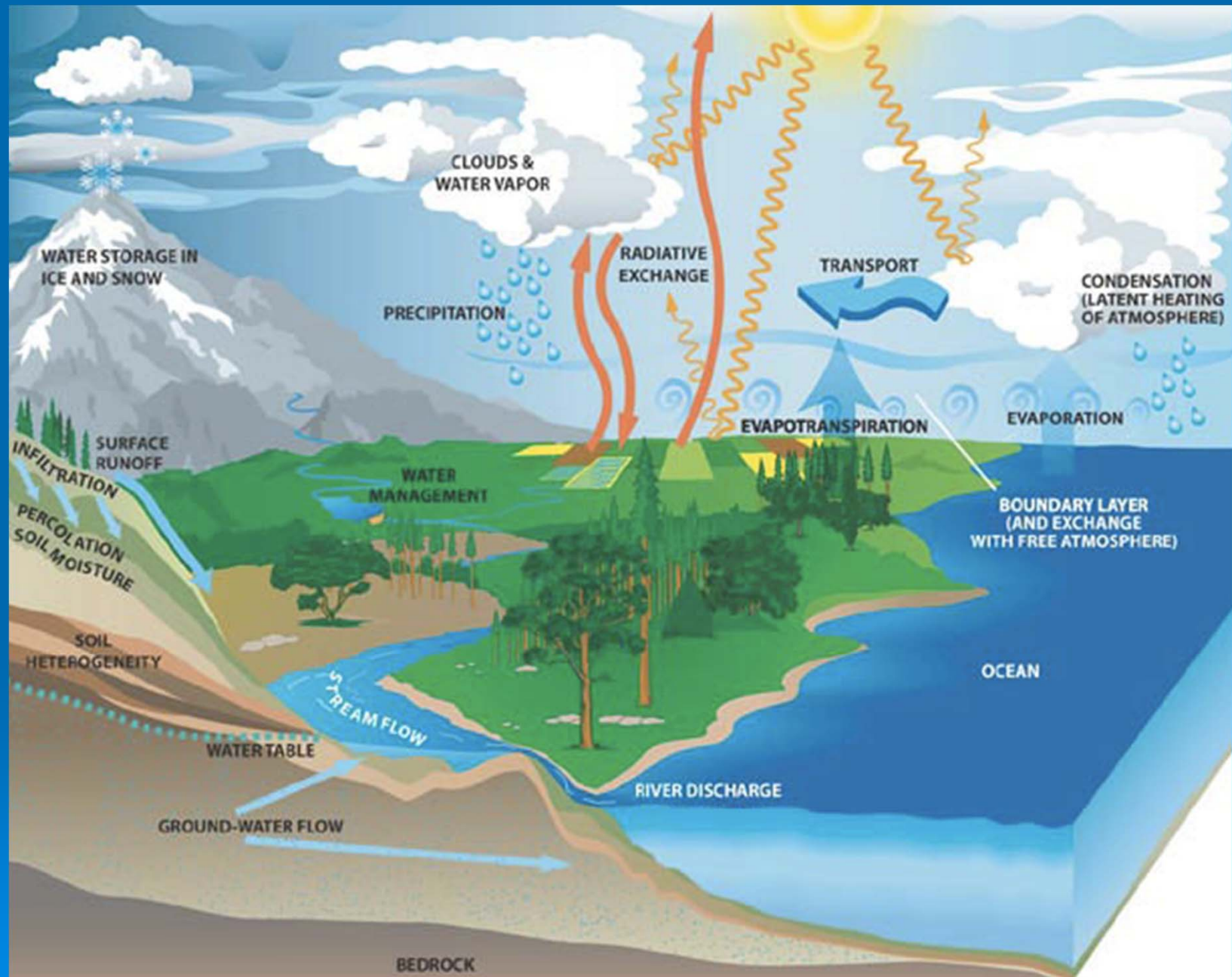


EDM Flow Diagram



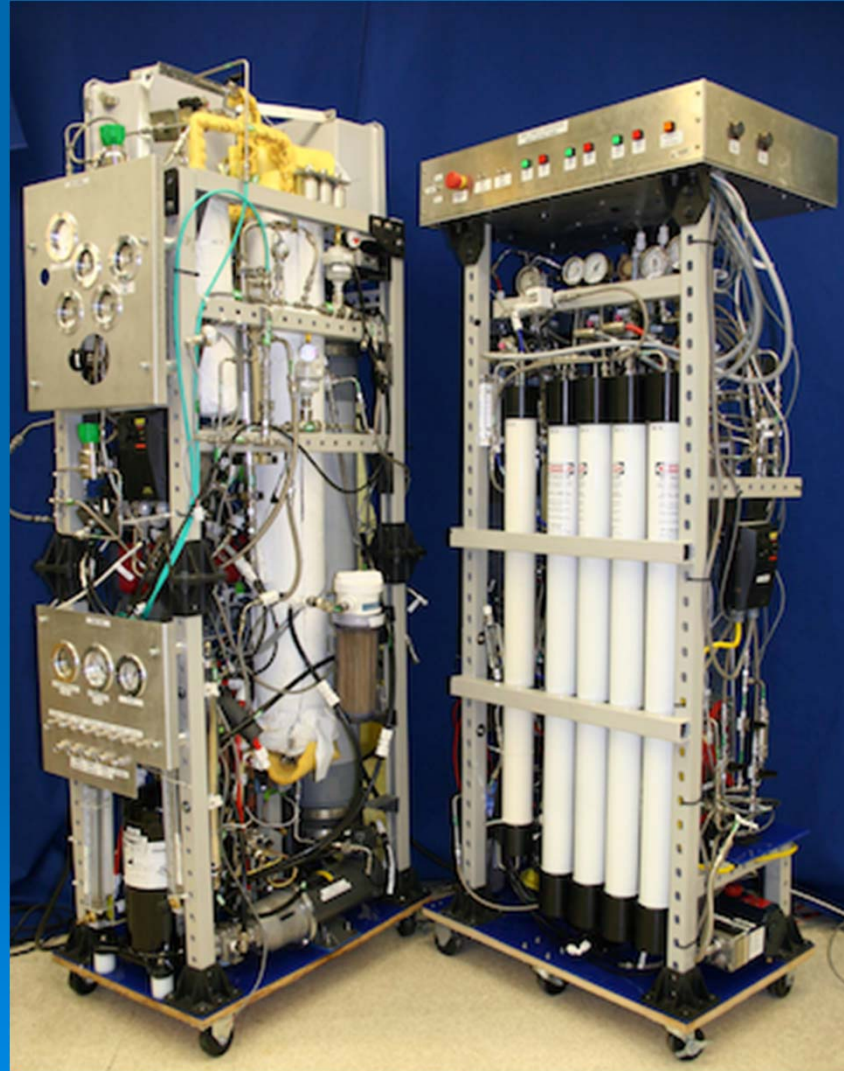
# Vapor Phase Catalytic Ammonia Reduction



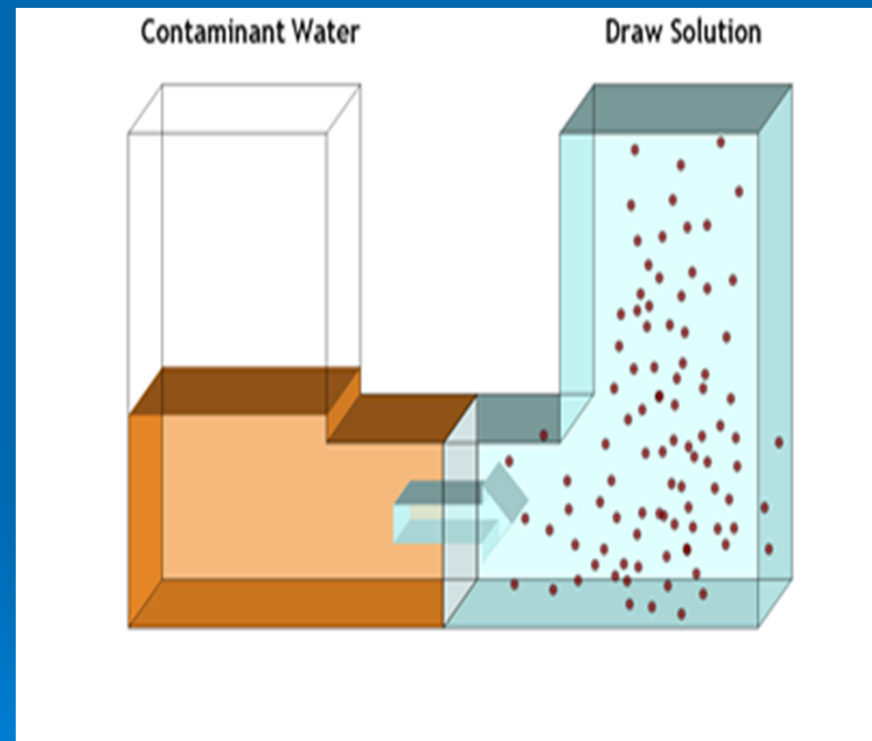
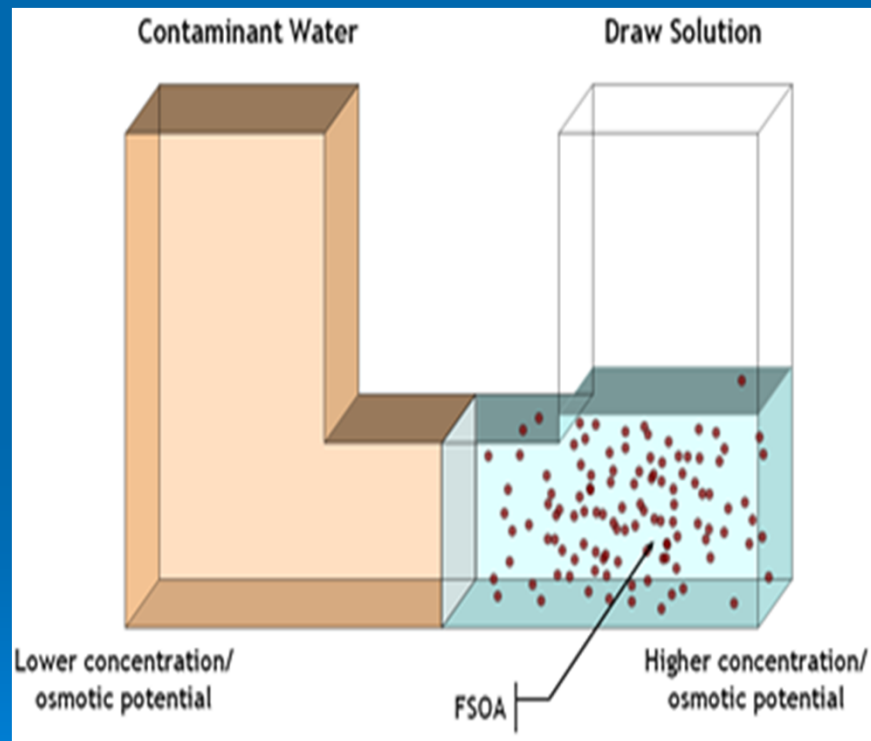




# Forward Osmosis

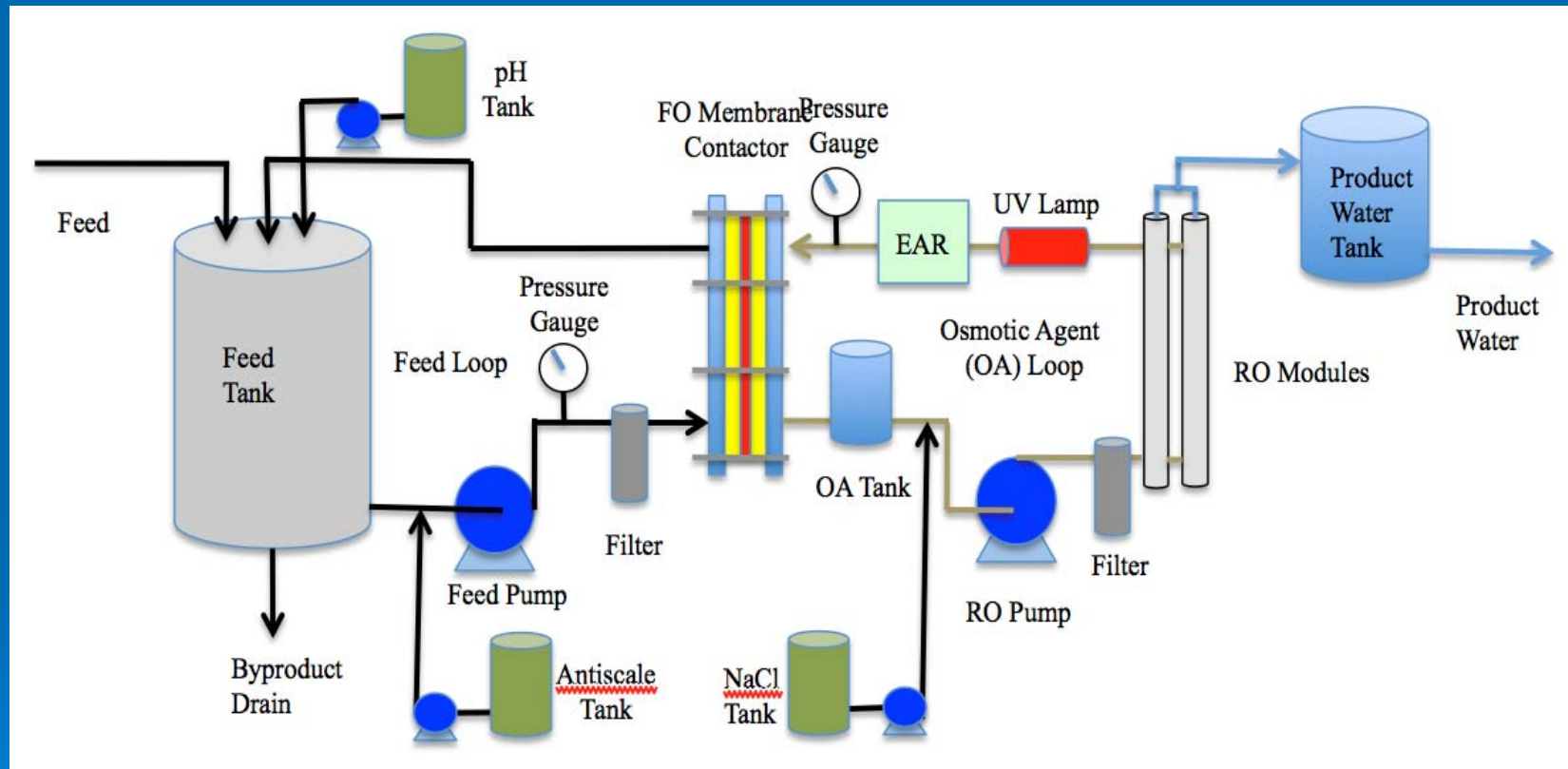


# Forward Osmosis

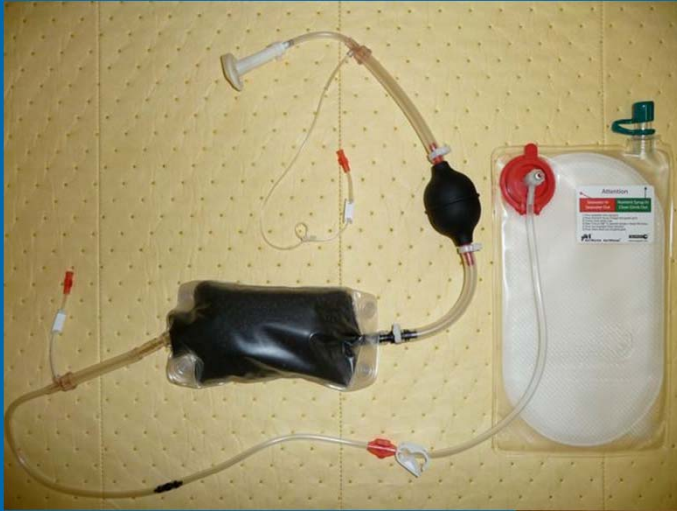




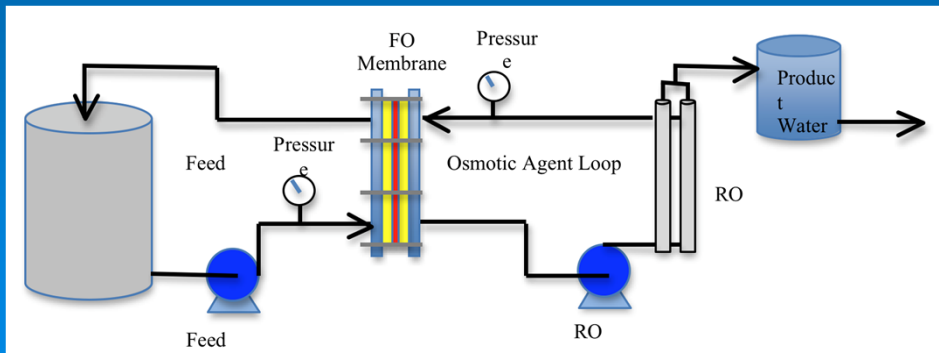
# Forward Osmosis Secondary Treatment



# Light Weight Contingency Water Recycling System



# Graywater Recycling

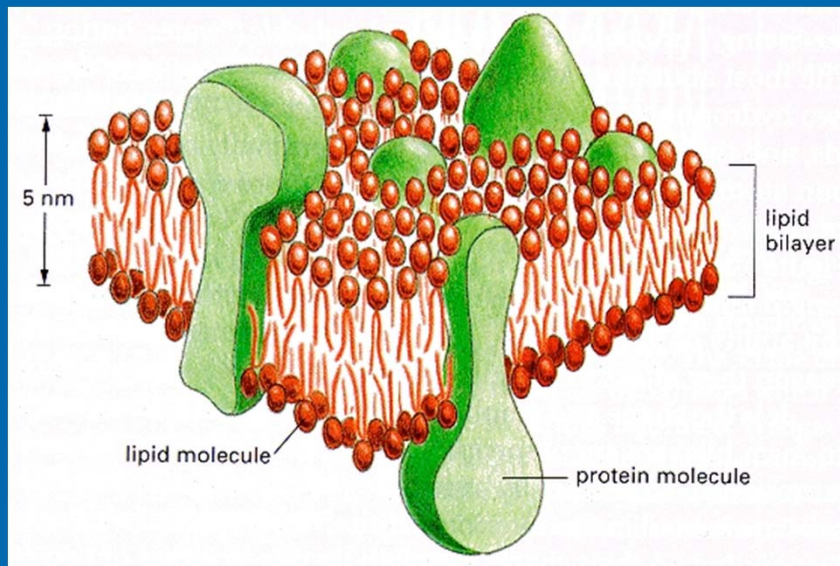




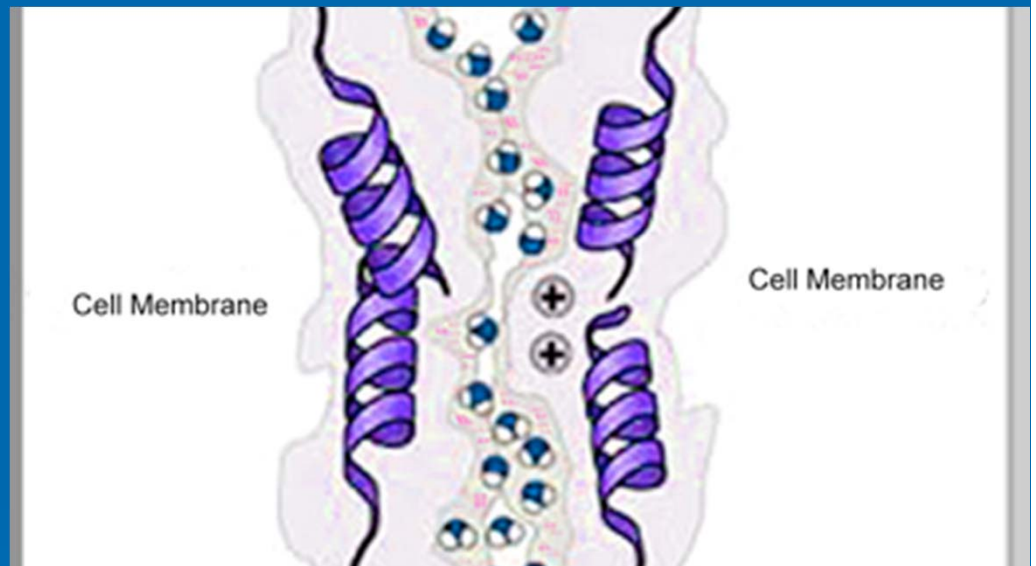
# Osmotic Distillation



# Advanced Membranes



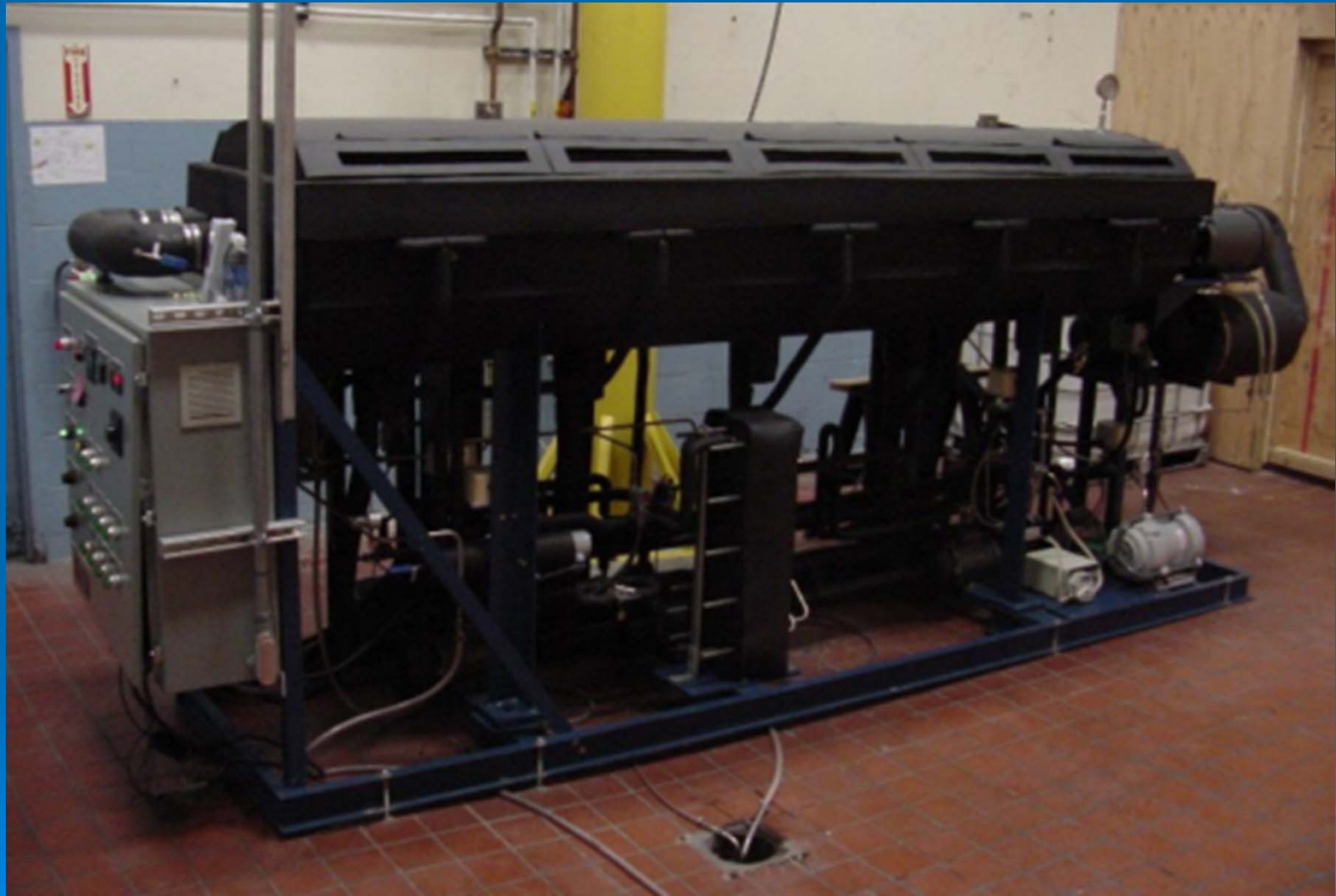
Lipid Bilayer Membranes



Aquaporin Embedded Protein Membranes

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

# Food Processing



Wiped Film Rotating Disk Evaporator



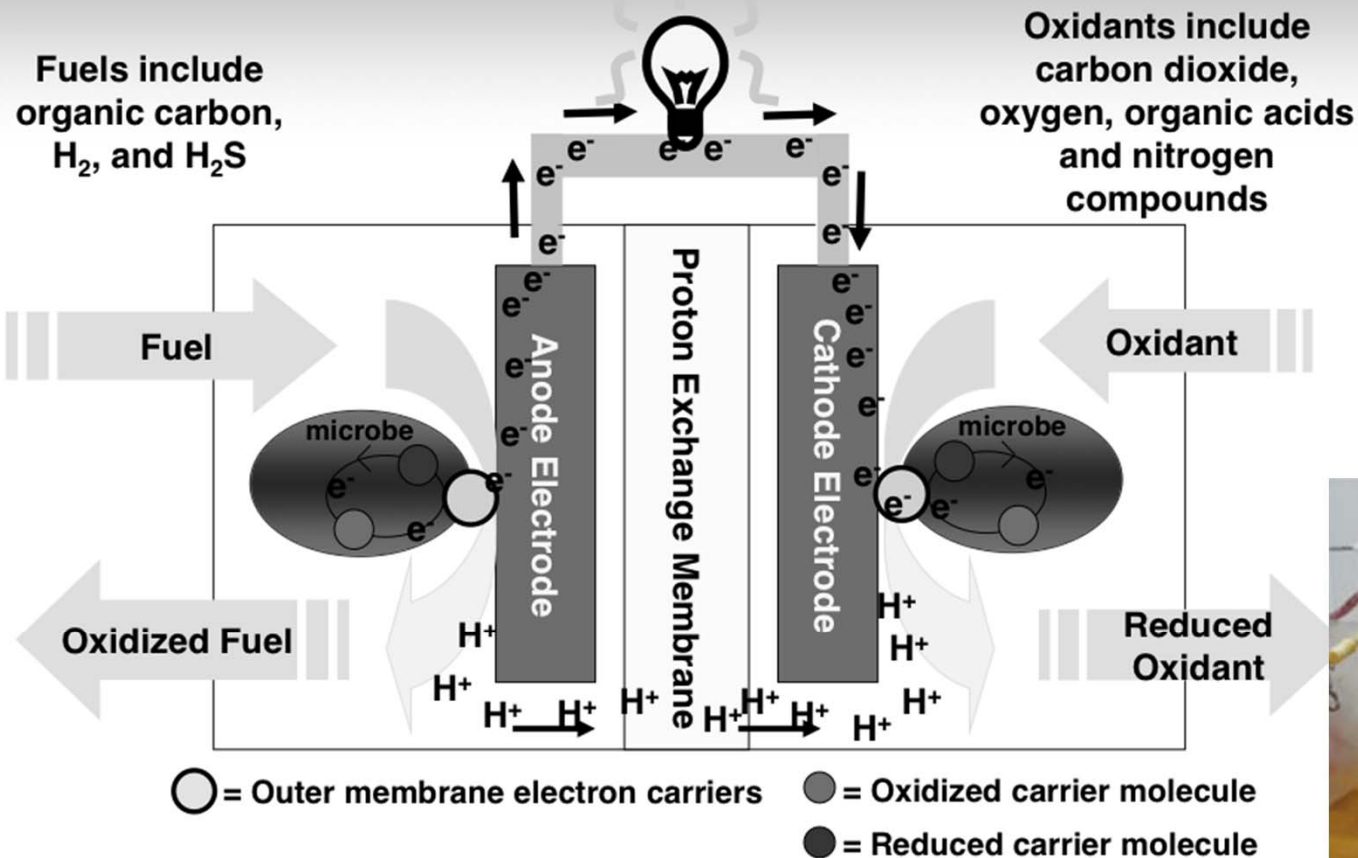
# Seawater Desalination



Environmentally Sustainable Desalination

# Biological Fuel Cells

## Microbial fuel cell - a version of BES

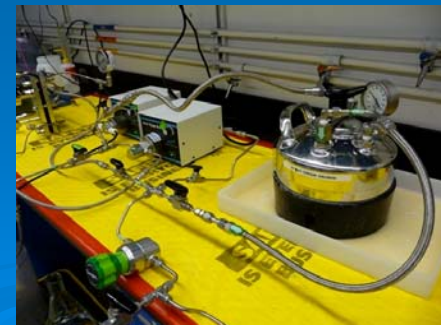
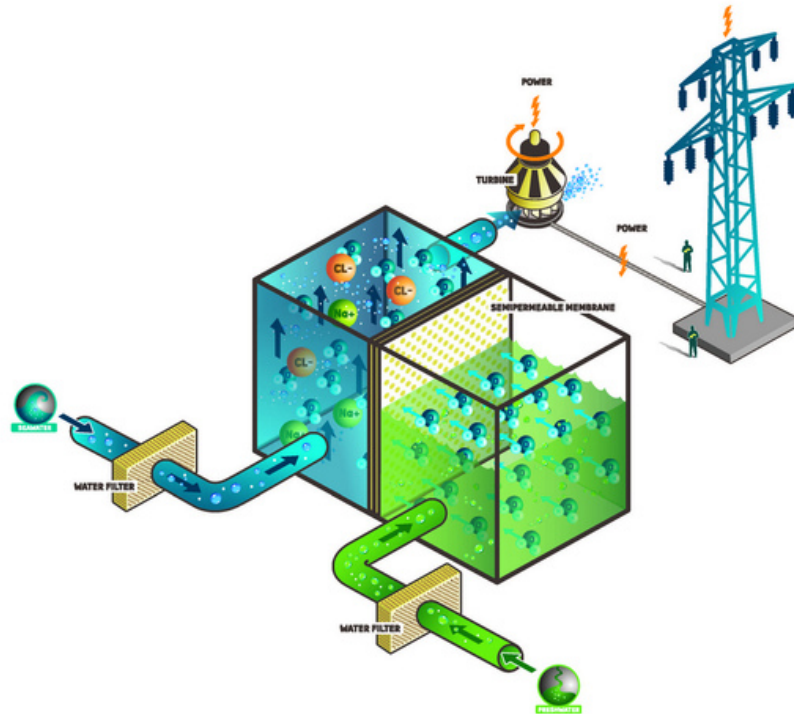


J. Craig Venter

I N S T I T U T E

# Osmotic Power

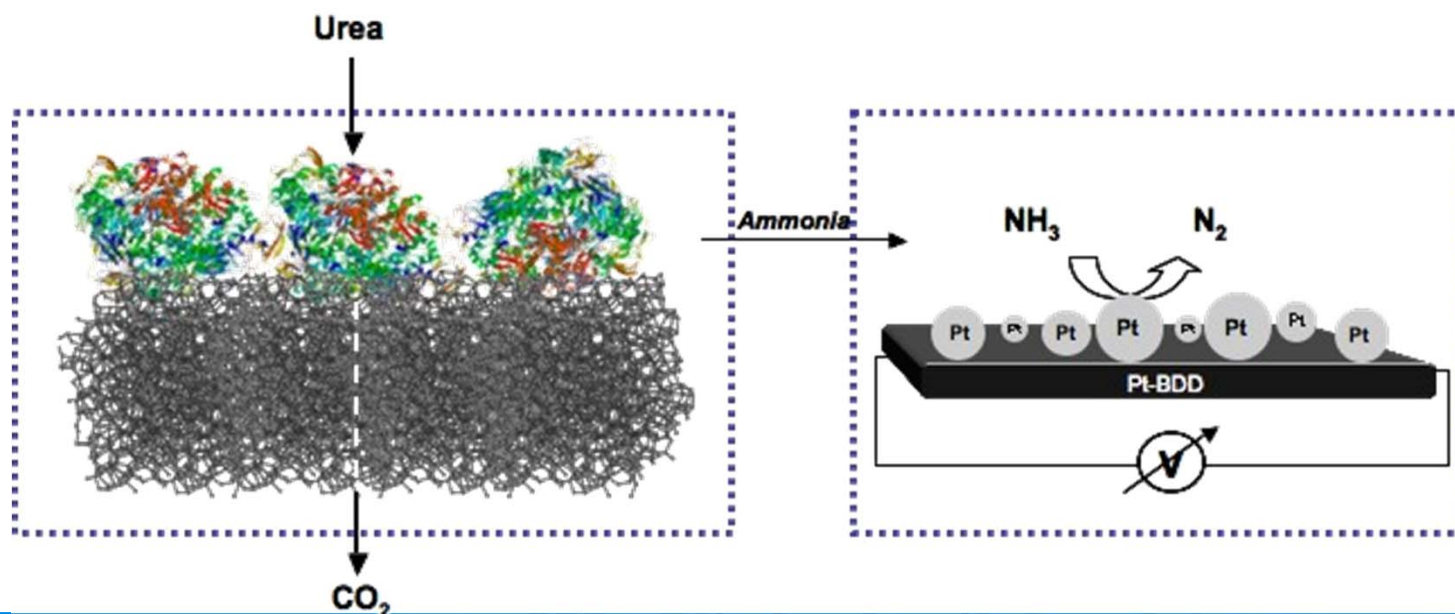
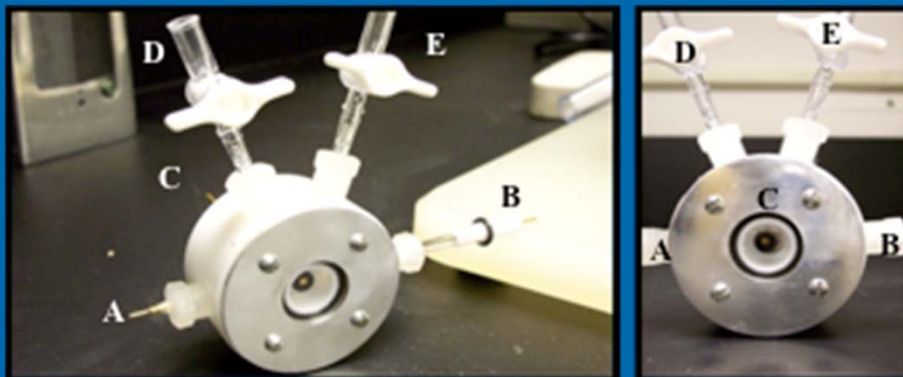
## → SEMIPERMEABLE MEMBRANE





# Ammonia Fuels and Cells

## Urea Biofuel Cell Reactor for Water Purification



# Water Recycling for Third World Applications

