Hamilton Sundstrand
A United Technologies Company

NIAC
NASA Institute for Advanced Concepts

# A Chameleon Suit to Liberate Human Exploration of Space Environments

Ed Hodgson
HSSSI

# Introduction

- **"To boldly go ……**
  - We've found that you need a spacesuit
  - Vacuum, radiation, extreme heat and cold, micrometeoroids
  - This sure isn't Kansas … So…

- **"Working in their bulky spacesuits …**
  - But does it have to be this way forever?
  - We think not!

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# Overview

- Study Foundations
- The Phase I Chameleon Suit Study
- The Phase II Study Concept
- The Emergence of Enabling Technologies
- The Study Plan
- Where It All Leads

# Extravehicular Activity (EVA) Systems Development History

**Life Support**
- Oxygen supply
- $CO_2$ removal
- Humidity
- Waste heat
- Trace contaminants
- Pressure control
- Gas circulation

**Information Systems**

**Pressure Suit (Isolation)**
- Insulation
- Pressure barrier
- MMOD
- Radiation

- The base paradigm – "Protecting the human from a hostile environment"
- Subsystem architecture
  - Protective pressure suit
  - Life support
  - Communication & information

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# Human Systems In Every-Day Life

- Environmentally adaptive & connected
  - Multi-tiered control
  - Broad tolerance
- Functionally integrated
  - Multi-purpose systems
  - Distributed functions

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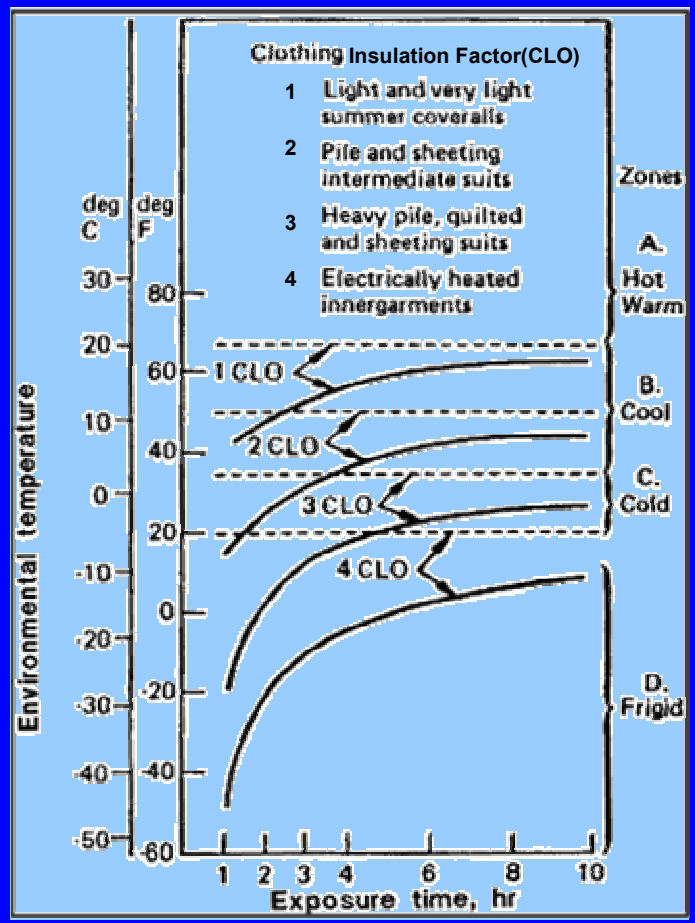
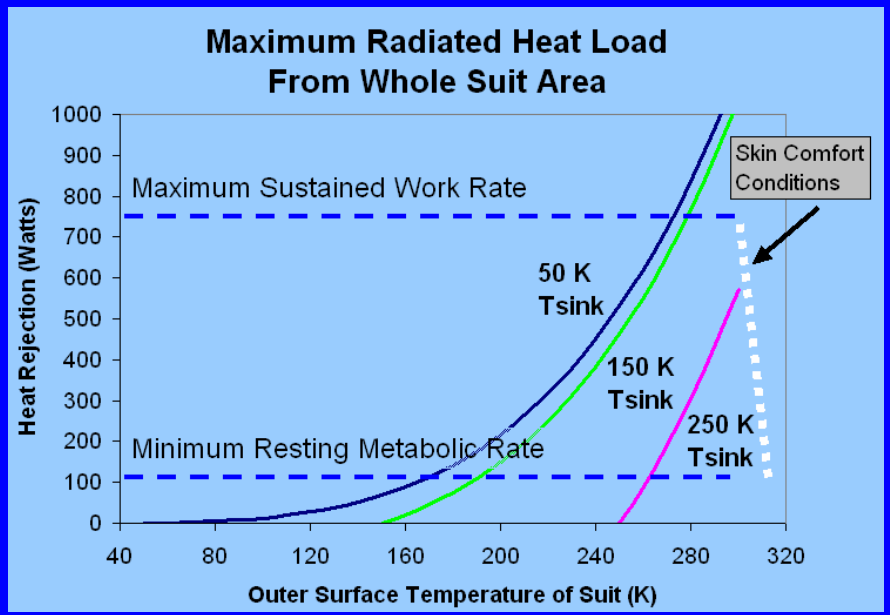
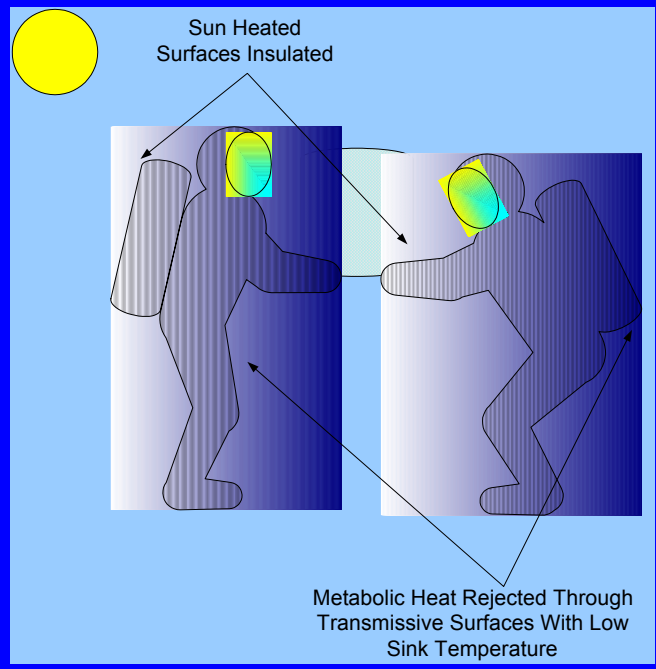



From: NASA STD 3000

# The Phase I Chameleon Suit Study

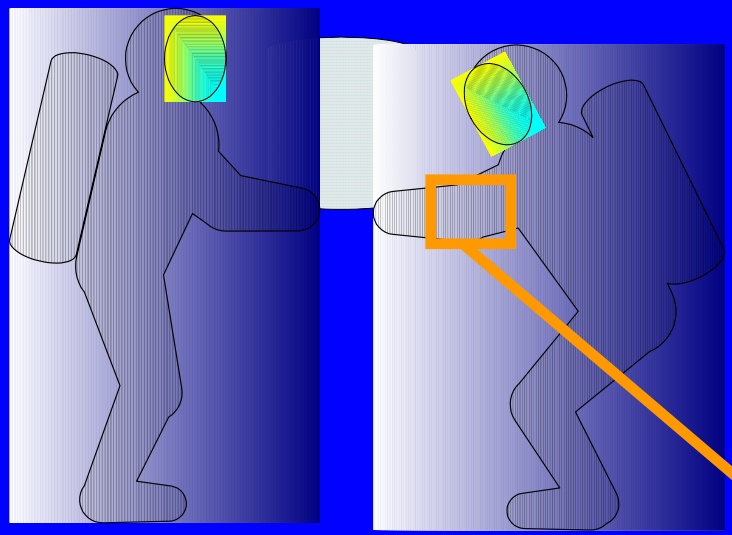
- Testing a new space-suit paradigm:
  - Working with the environment
  - Integration of life support and pressure garment



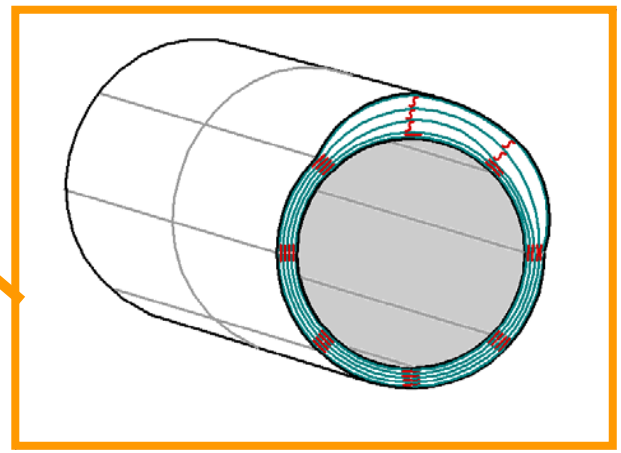




- Focus on thermal management
- Applying emerging technologies

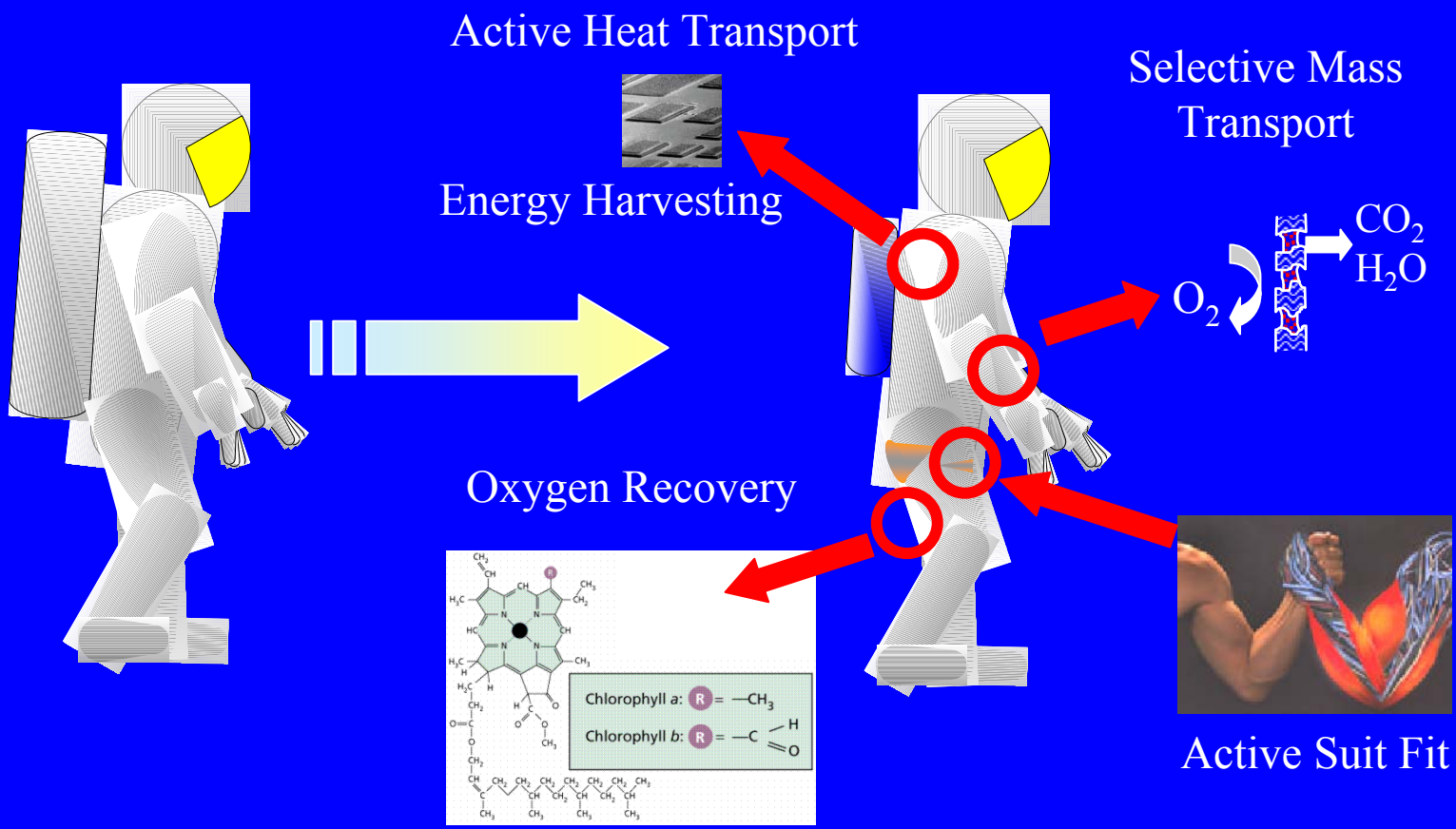
# The Phase I Chameleon Suit Study



- According t[illegible] mental condition
  - Var[illegible] poly[illegible] spacin[illegible]
  - Vary layer en[illegible]

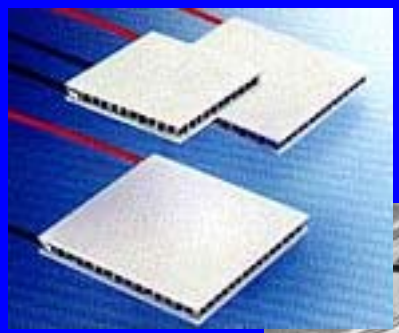


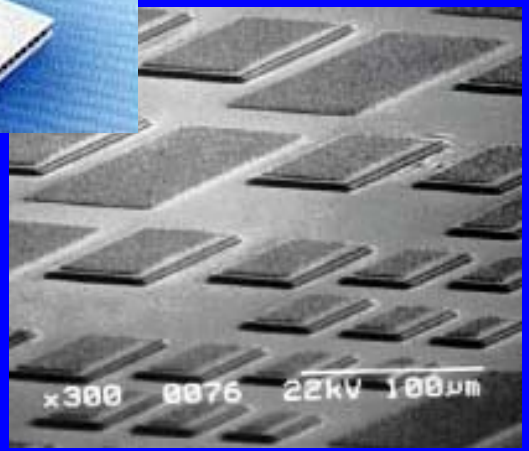
# The Phase II Study Concept

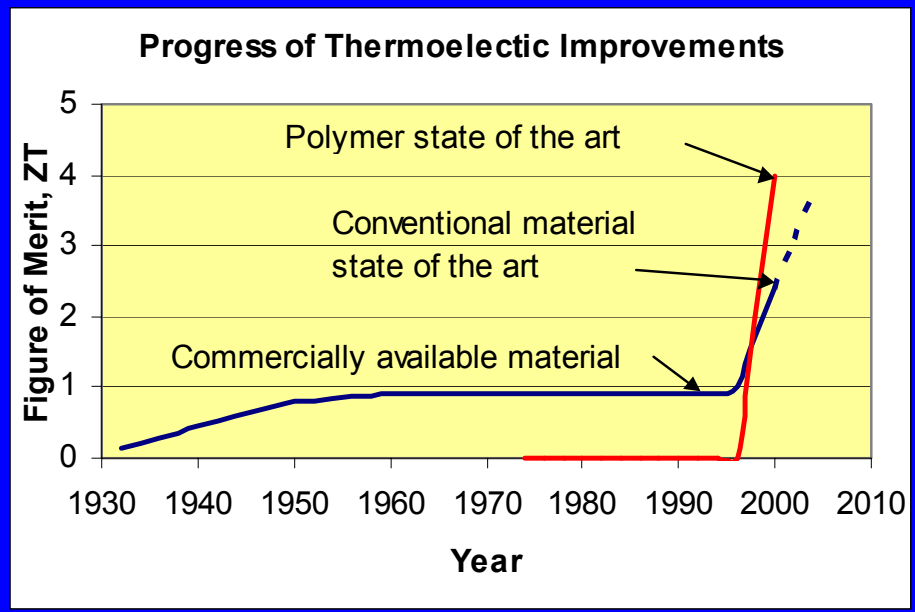


# Active Heat Transport Technology

- Micro-machines
- Thermoelectrics
- Recent breakthroughs in performance
- Flexible thermoelectric polymers
- Distributed thin-film modules



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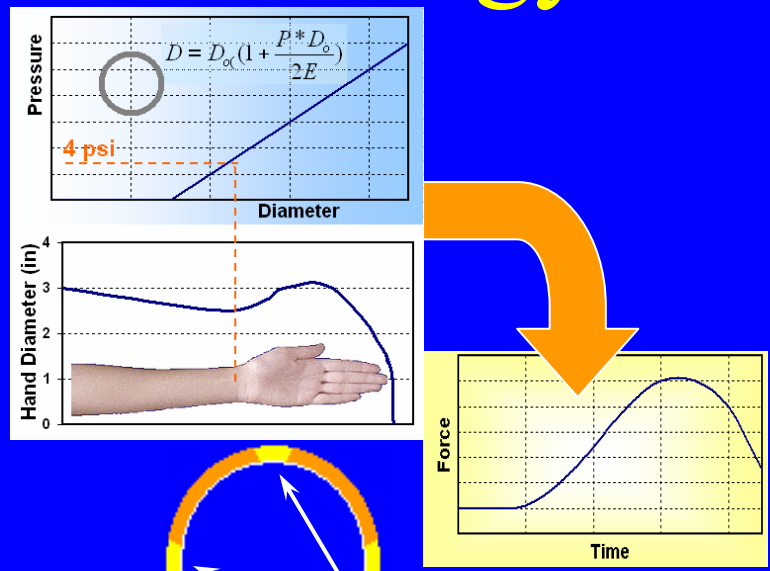
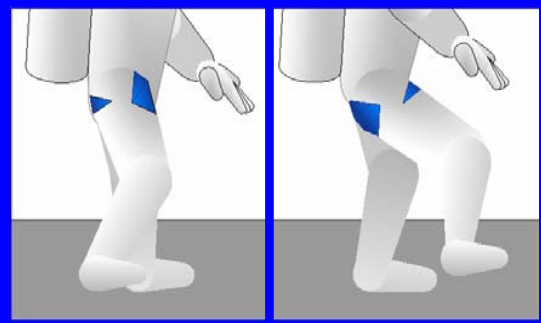
# Active Suit Fit Technology

- Personal & variable fitting
- Mechanical Counter Pressure (MCP) increases mobility & flexibility
  - SMA mesh
  - Smart gels
- Joints
  - Unidirectional Stretch Fabric
- Active mobility support

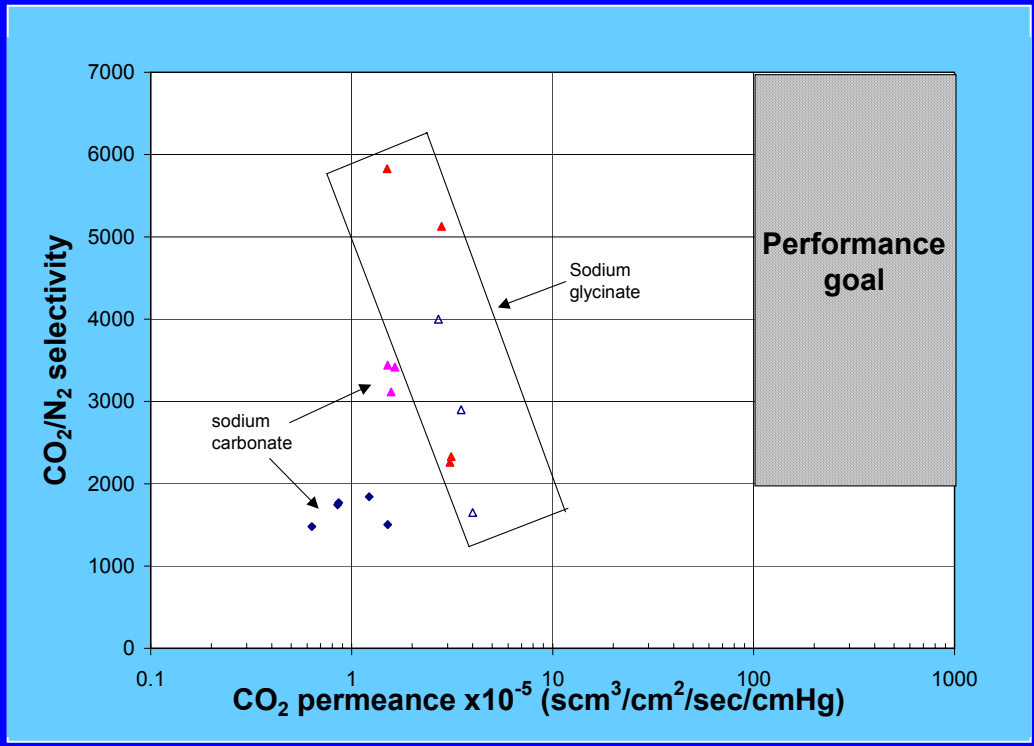




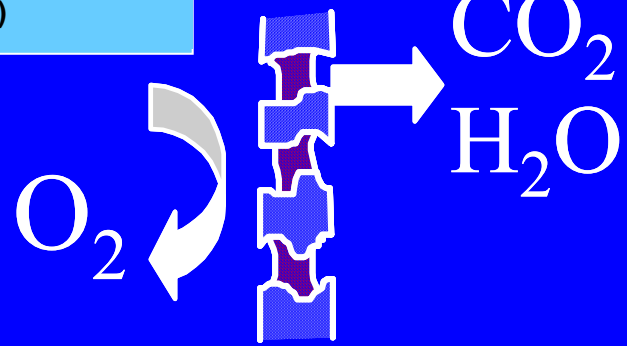

Active Fit Mat'ls



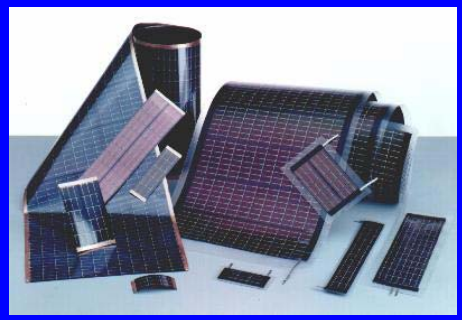
# Selective Mass Transport Technology

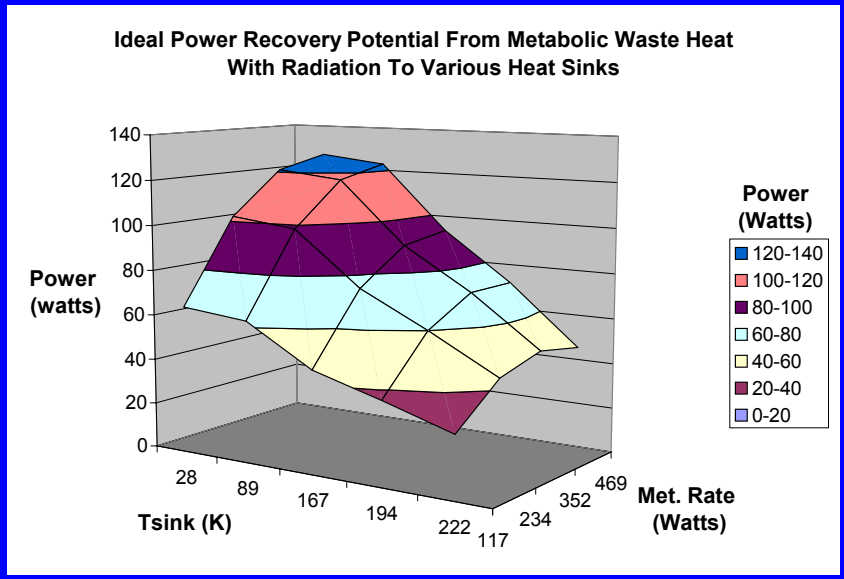



- Separate $CO_2$, $H_2O$ from $O_2$ with minimal $O_2$ loss
- Facilitated transport of $CO_2$ through chemical reaction
- Facilitators immobilized in membrane



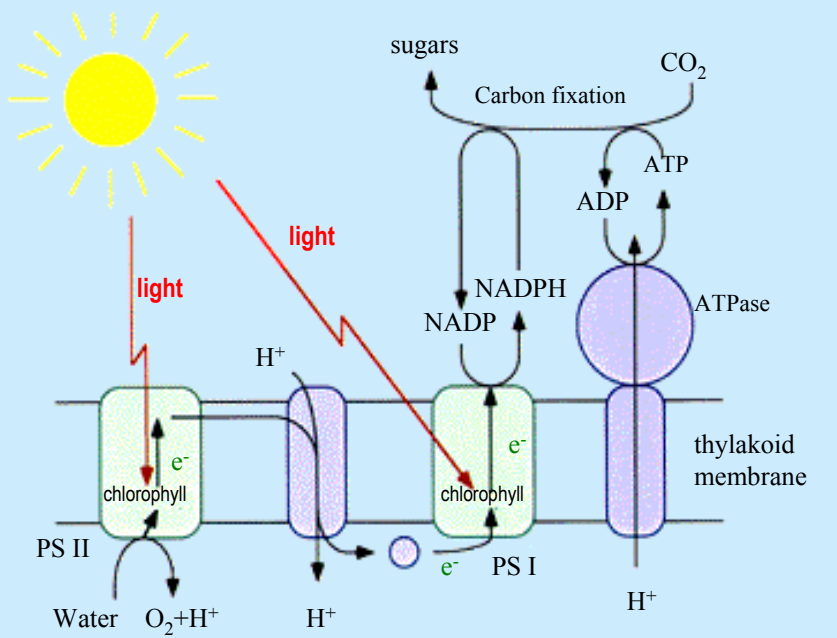
# Energy Harvesting






- Incident Sunlight
  - Increased solar cell efficiency
  - Thin, flexible solar arrays
- Waste Metabolic Heat
  - Lower radiating temperatures
  - Thermoelectric heat pumps
- Reduce battery size
- Local storage eliminates need for power distribution

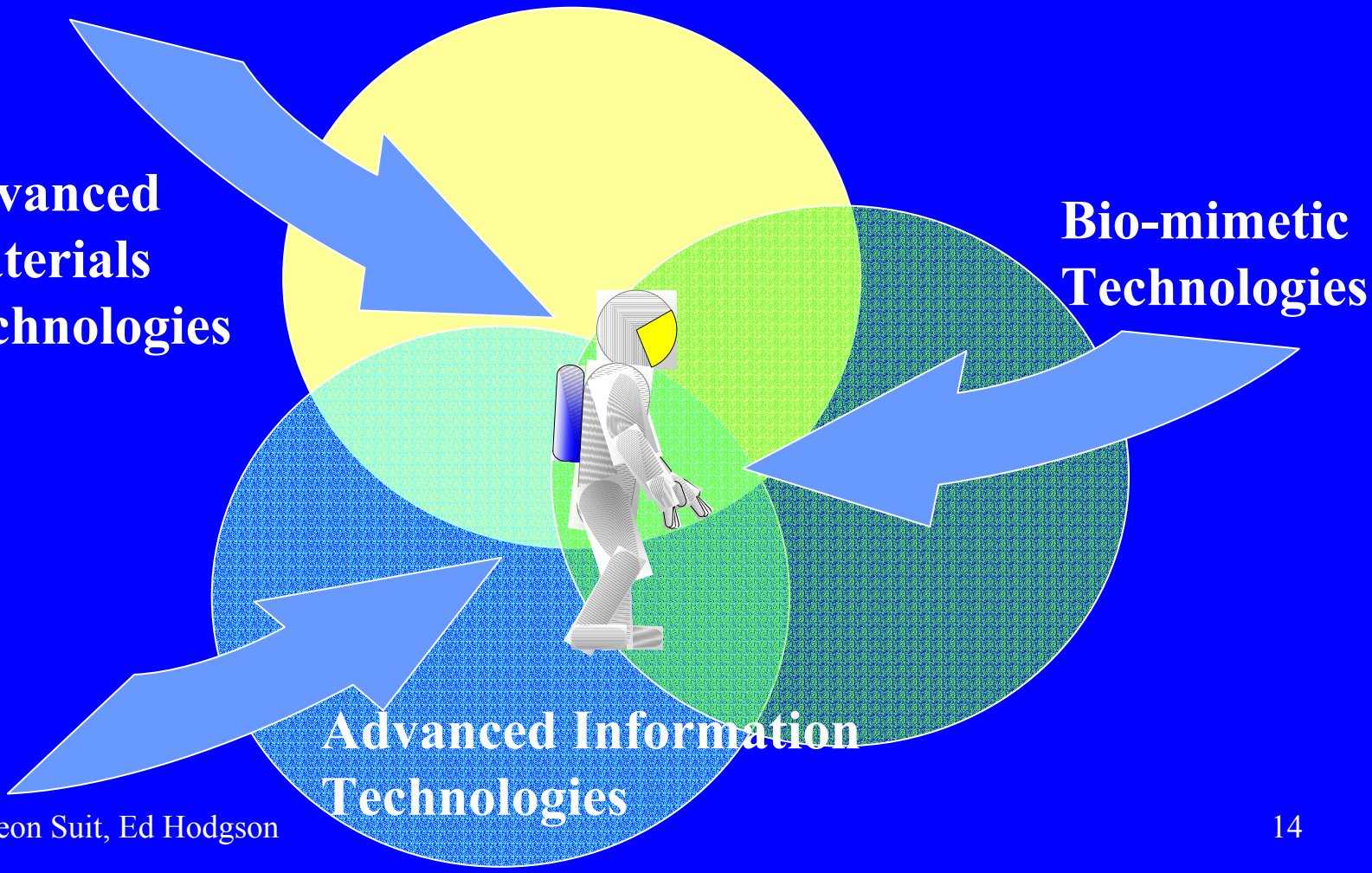
# Oxygen Recovery – Artificial Photosynthesis




http://photoscience.la.asu.edu/photosyn/education/photointro.html

- Transform $CO_2$, $H_2O$ back into $O_2$ and fuel
- Thermo-chemical reactions, electrochemical reactions, catalysis
- Interest from environmental, biochemistry, medical fields

# The Emergence of Enabling Technologies

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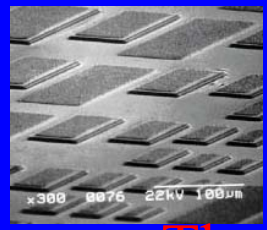
# Advanced Materials Technology

Molecular Design Capabilities

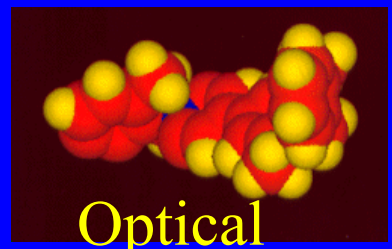
Nano-assembly Capabilities

**Engineered Polymers / Nano-composites**

**Functional Materials**

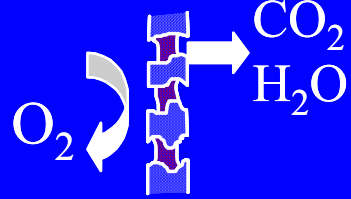


Thermal

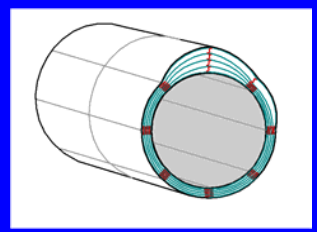


Optical

Chemical




Mechanical



# Advanced Information Technologies

CAD / CASE Tools

Connectivity/ Networking Technologies

Advanced Manufacture

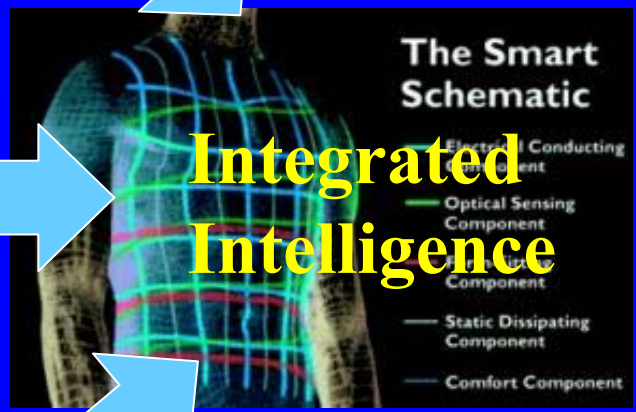
Managing Complexity

Reducing Scale

Increasing Speed

Advanced Integration

**Smaller, Faster, Cheaper, Systems**




Advanced, Electrically Active Materials

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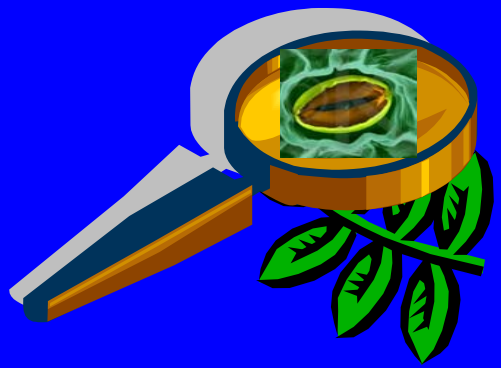
# Bio-Mimetic Technologies

## Learning from nature

Understanding biological materials and processes



Biologically inspired designs and approaches

Self assembling systems


Biocatalysts

Bio-membranes

Engineered Bio-mimetic Designs

Artificial Muscles

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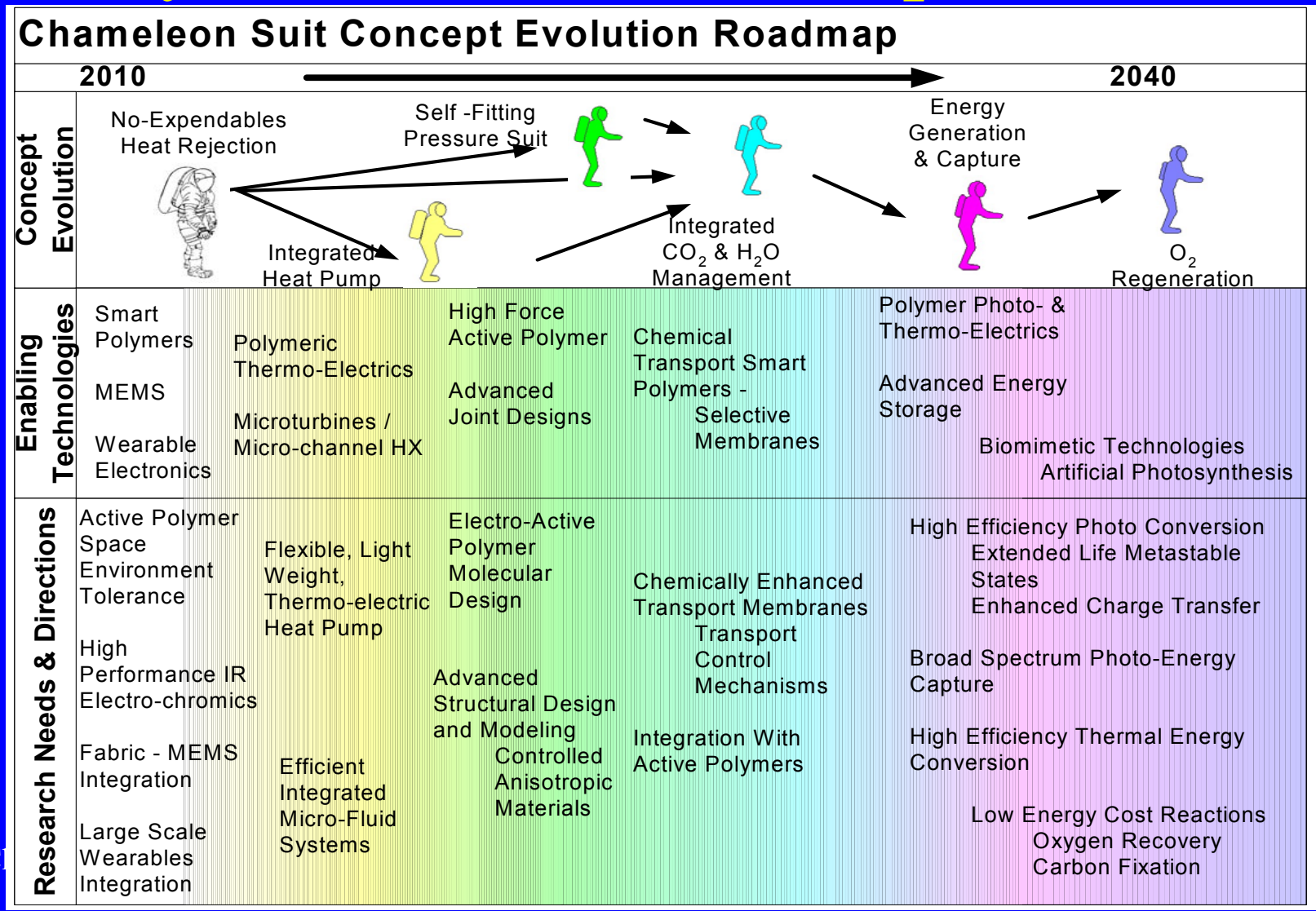
# The Study Plan – What We Are Doing About It

- Technology exploration
- System concept development
- System concept characterization
  - Prioritization and selection
- NASA coordination
- Technology needs and potential assessment
- Roadmap definition

# The Study Plan
# System Evolution Perspective



# Where It All Leads