

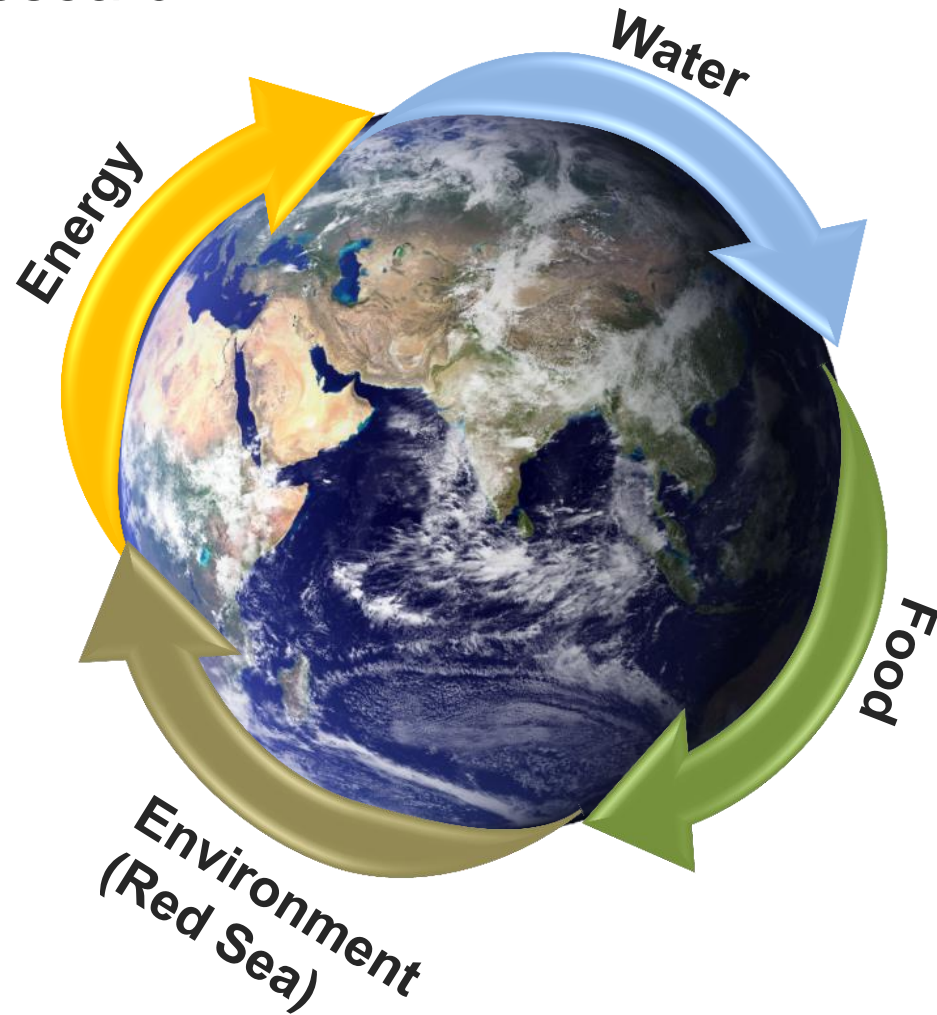


Building a global science and technology university focused on sustainability: The KAUST research and education programs on separation science and technology



ACS Meeting on Separation Science and Technology, San Francisco, 2014

Committed to
cutting-edge research in:



KAUST evolving from a start-up to an operating University model



Dr. Jean-Lou Chameau

Ph.D. Civil Engineering (Stanford)

جامعة الملك عبد الله
للعلوم والتقنية

King Abdullah University of
Science and Technology





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Campus

Where is KAUST?

- 36 million m² campus
- On the Red Sea in Thuwal
- 80KM north of Jeddah



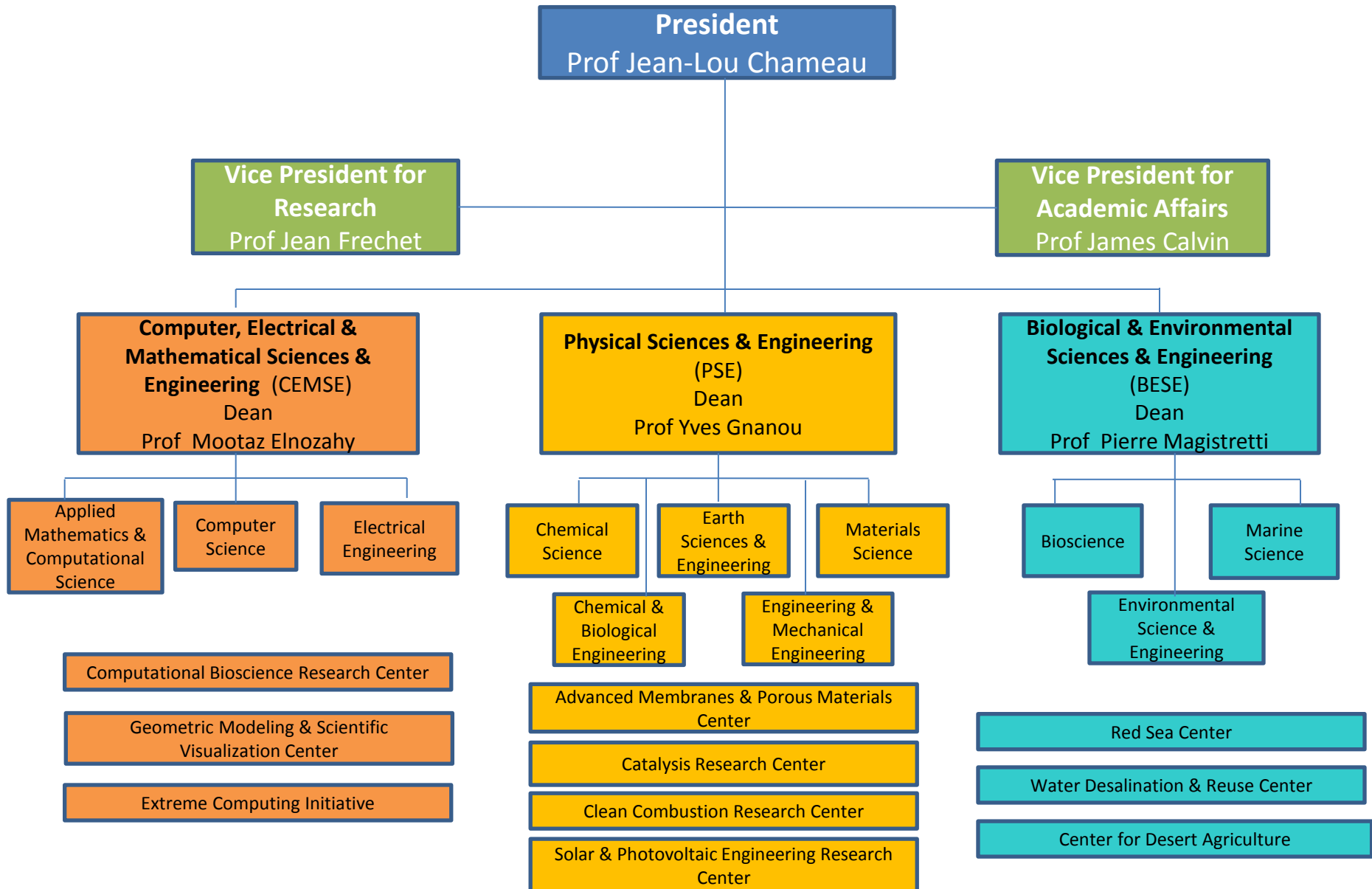




The University is the first LEED® certified project in Saudi Arabia and the largest LEED® Platinum project in the world.



Academic Structure



Education

KAUST: Fast Facts

- Language of Instruction: English
- Merit-based, graduate research university
- Both M.S. and Ph.D. degrees are research focused
- Eleven Science & Engineering programs organized in three Divisions
- Nine Research Centers and Seven Core Lab Facilities
- At maturity:
 - KAUST will have **1,800-2,000** students
 - KAUST will have **225** faculty members
 - Full research community will consist of **1,500** members (plus students)
- Currently:
 - 740 students (over 30% female and over 70% pursuing PhD)

Divisions & Degree Programs

3 Academic Divisions

**Biological and Environmental
Science & Engineering**

**Computer, Electrical and
Mathematical
Science & Engineering**

Physical Science & Engineering

11 Degree Programs

Bioscience

Environmental Science & Engineering

Marine Science

Applied Math & Computational Science

Computer Science

Electrical Engineering

Chemical Science

Chemical & Biological Engineering

Earth Science & Engineering

Mechanical Engineering

Materials Science & Engineering

The KAUST Degrees

- **MS** – Three semesters of academic work and summer program allows options for internships, research, courses
- **MS with Thesis Option** – Three semesters of academic work, a summer program, and a thesis, possibly requiring additional time (requires faculty approval and advisor)
- **PhD** – Typically a three- to four-year, post-master's degree; involves original research in a KAUST program culminating in a research thesis
- **MS/PhD** – Typically four to five years; Students start their Ph.D following the completion of their BS degree and undertake research from the start of their program.
- **Internship Program** – Available both for students wishing to visit KAUST and for KAUST students wishing to become involved in external activities

Research

The KAUST “Research Enterprise” is growing...

132 Faculty members *(at maturity: 220)*

- 54 in Physical Sciences and Engineering (PSE)
- 38 in Biological & Environmental Sciences & Engineering (BESE)
- 40 in Computer, Electrical and Mathematical Sciences and Engineering (CEMSE)

740 students *(at maturity: 1,800-2,000)*

- > 30% female
- 70% in Ph.D. programs
- 30% in Masters programs

350 postdocs *(700+ at maturity)*

250 Research Scientists *(500 at maturity)*

Research Funding at KAUST

- All Faculty receive assured yearly “baseline” funding (no overhead).
- Project funding from Research Centers
- Additional start-up funding for new Faculty
- Access to competitive funding with ca. 40% success rate
- Access to yearly equipment allocations
- Access to workshop/conference funding
- Access to seed-funding for start-ups

Research Funding at KAUST

Faculty Baseline funding varies from about 325K/year to \$1M/year depending on both field and standing in the field.

Competitive 3 year grants allow our PIs to select and fund external collaborators.

Center funding (*ca.* \$5M/Year) includes 3 components:

- Yearly baseline for Center operation
- Project funding awarded for 6-8 years with latitude to fund external collaborators.
- Starting in 2015 each Center will have its own seed fund

Research Funding at KAUST

Office of Competitive Research Funds (OCRF) Internal Funding Entity

Program planning and implementation of competitive funding programs

Award documents, award progress monitoring and integrative activities (i.e., TTI)

Office of Research Services (ORS) Recipient Entity of External and Internal Funding

Provide administrative, financial and contractual support to faculty in acquiring internal and external funding

Support for faculty grant application: budget development, project development, and award management

Research @ KAUST combines quality and relevance to the Kingdom

Research Centers and Individual Faculty Laboratories

Combining fundamental and goal-oriented research:

Advancing science and engineering while pursuing technological innovation & economic development in areas of importance to the Kingdom of Saudi Arabia.

50% of our Faculty are affiliated with our research centers

Core Laboratories

Providing support for research with highly trained technical staff and state-of-the-art facilities.

Analytical services, Instrument development, new techniques, training of scientists and engineers...

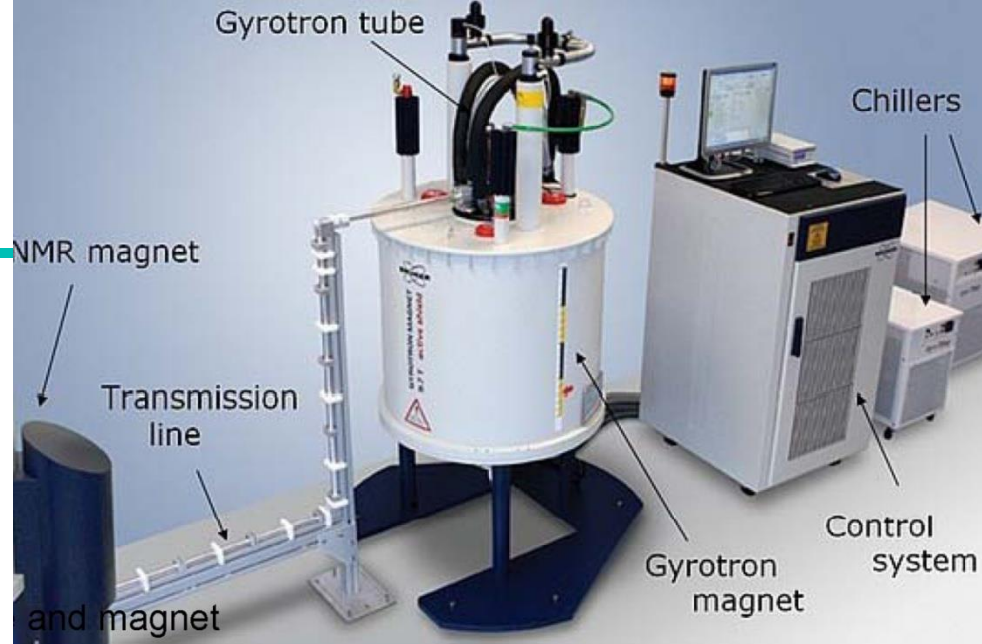
Our central support facilities (Core Labs) are constantly being upgraded

- Analytical facilities
- Nanofabrication,
- Imaging & characterization
- Biosciences – genomics, proteomics
- Supercomputing
- Visualization & image processing
- Coastal marine, oceanography
- Central workshops

Arriving in mid-2014: Solid-state DNP-NMR

263 GHz solid-state DNP-NMR Spectrometer.

DNP uses the large thermal polarization of the electron spin reservoir of a paramagnetic polarizing agent to provide a **sensitivity boost for NMR experiments—by several orders of magnitude.** In a DNP experiment, the electron polarization is transferred to the nuclei by microwave/terahertz radiation of its electron paramagnetic resonance (EPR) transition.

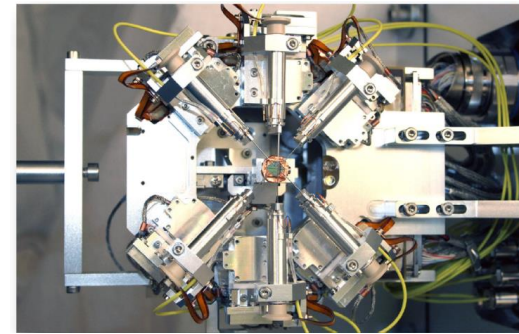




Plasma enhanced metal organic
chemical vapor deposition
(MOCVD) tool to study hetero-
structured materials



New SEM with d-prober – 5 nm nanomanipulator
resolution with XYZ sample stage & parametric
analyzer



EPR Spectrometer



Hall effect measurement system

Coastal Marine Laboratory: New Research Vessel



R/V Thuwal

All of our Research Centers are in operation

Catalysis – *Jean-Marie Basset*

Clean Combustion – *Sukho Chung*

Computational Biosciences – *Vladimir Bajic*

Desert Agriculture – *Heribert Hirt*

Membrane and Porous Materials – *Ingo Pinnau*

Water Desalination and Re-use – *Gary Amy/TorOve Leiknes*

Red Sea – *Xabier Irigoyen*

Solar Photovoltaic – *Karl Leo*

Visual Computing - *Wolfgang Heidrich*

New Developments at KAUST

- 2014-15 - **Extreme Computing Research Center** led by Prof. David Keyes. Start of the Center will roughly coincide with the arrival of our new supercomputer.
- 2014-15 – Creation of an **animal facility**
- 2015 - **Petroleum Engineering Research Center**. Currently in the planning stages.
- 2015 - **Seawater Greenspace**. Currently in the planning stages

KAUST Strategic Research Thrusts

❖ Water

❖ Energy

❖ Food

❖ Environment



- All of our Thrusts rely heavily on MATERIALS
- All of our Thrusts connect science & engineering

The KAUST Water Thrust

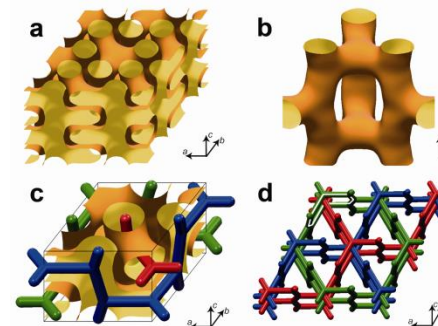
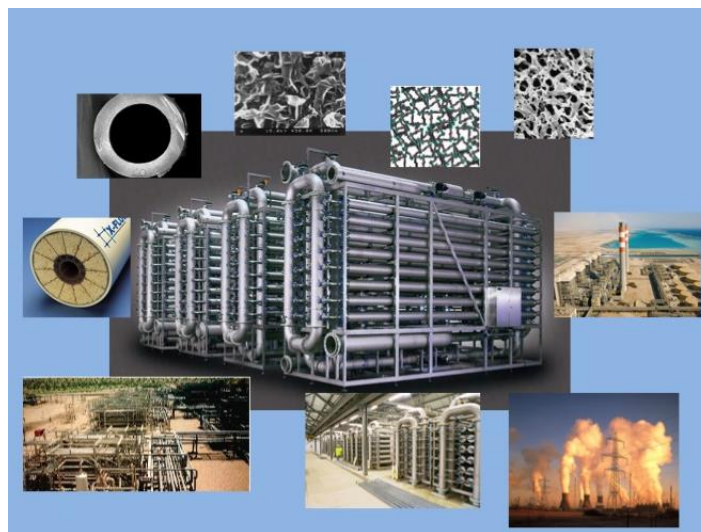
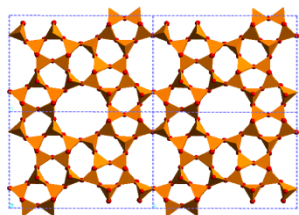
The KAUST Water Thrust involves two of our Academic Divisions and three of our nine Research Centers:

- **Water Desalination and Reuse Center:** *Engineering the future technologies for sea water desalination, purification and recycling of used water, and reservoir management.*
- **Membrane and Porous Materials Research Center:** *new membranes and adsorbent materials for water purification*
- **Desert Agriculture Research Center:** *wind and sun-powered greenhouses for coastal agriculture; development of drought and salt tolerant crops*



Advanced Membranes and Porous Materials Center - Overview

Ingo Pinnau



The Mission of Membranes and Porous Materials in the 21st Century

Develop Sustainable Clean Energy and Water Production Technologies



Efficient and Sustainable Separation/Storage Processes

Advantages of *Advanced* Membranes and Porous Materials

- Least expenditure of energy and least generation of waste
- Technology can be applied over a very broad separation spectrum
- Reliable, modular, simple operation, easy process integration
- Cost effective

KAUST Advanced Membranes and Porous Materials Center: General Directions

Modeling

- Process design
- Molecular materials design

Materials

- Advanced Polymers
- Inorganic Materials
- Composite Materials
- Liquids

Morphology

- Microporous/Nanoporous
- Integral-Asymmetric
- Thin-Film Composites
- Membrane Contactors

Modules

Hollow-Fiber, Spiral-Wound, Plate-and-Frame



AMPM Center: Current Faculty and Staff

Center
Director

Ingo Pinnau

Named Professor

Gas separation, reverse osmosis,
Polymer and carbon membranes

Administrative Staff

J. Nigel Metge (Center manager)

Sherry Shilling (Executive secretary)

Center
Faculty

<http://ampm.kaust.edu.sa/Pages/Publications.aspx>

Mohamed Eddaoudi

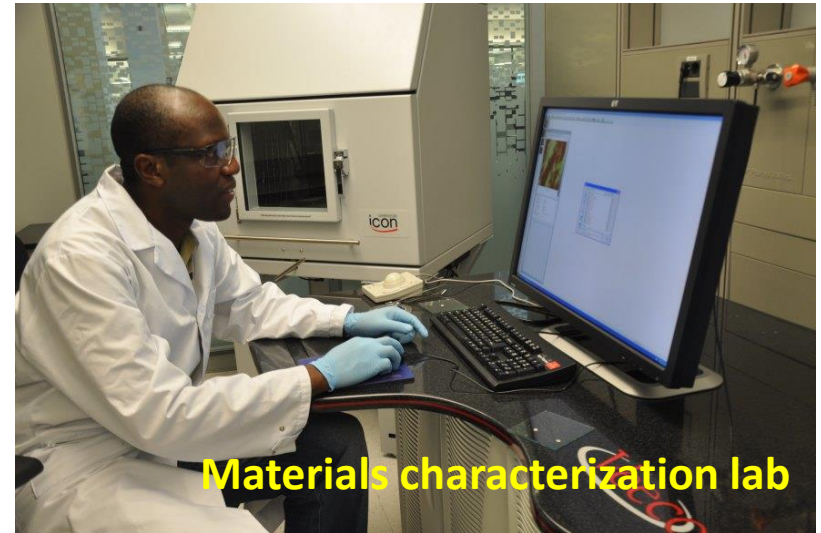
Associate Director - Full Professor - Inorganic chemistry, MOFs, porous materials

Klaus-Viktor Peinemann – Full Professor – Polymeric membranes, water treatment

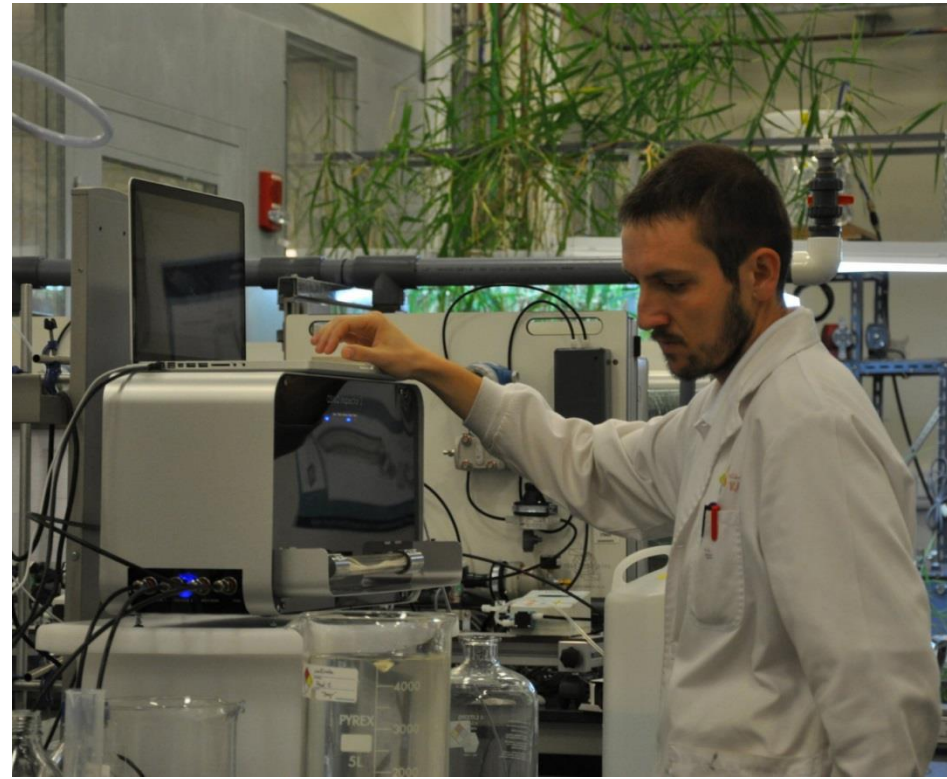
Zhiping Lai Associate Professor - Zeolites, mixed-matrix membranes, fundamental transport

Yu Han Associate Professor - Mesoporous inorganic materials, materials characterization, catalysis

Membrane and Porous Materials Research Center



Testing Novel Hollow Fiber Membranes in water purification



Mission of the Water Desalination and Reuse Center



Gary Amy

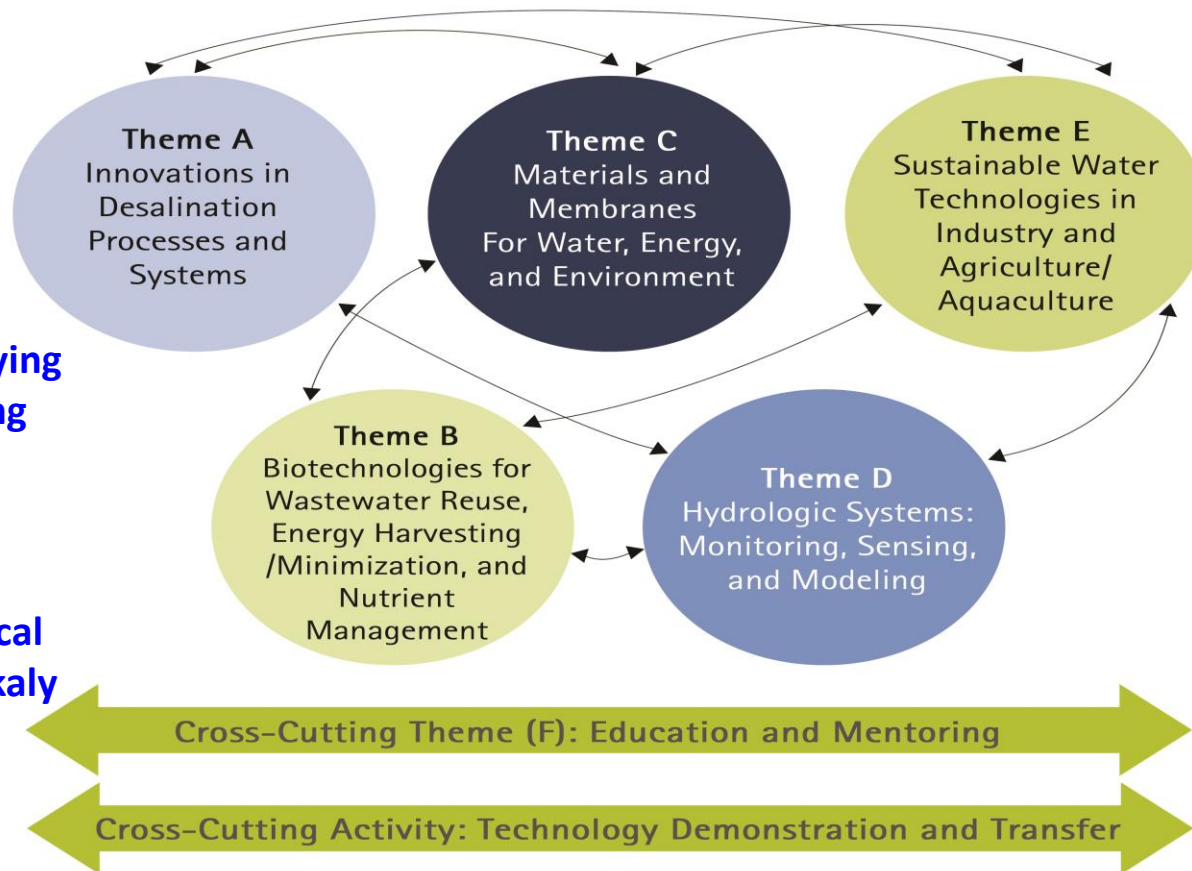


Peng Wang

Suzanna Nunes



TorOve Leiknes



Peiying Hong



Pascal Saikaly



Mathew McCabe

Water Desalination and Reuse Center

Targets:

Development of sea water desalination technologies with lower energy requirements and minimal environmental impact.

Development of energy-neutral processes for wastewater treatment.

Replenishment and management of aquifer resources.

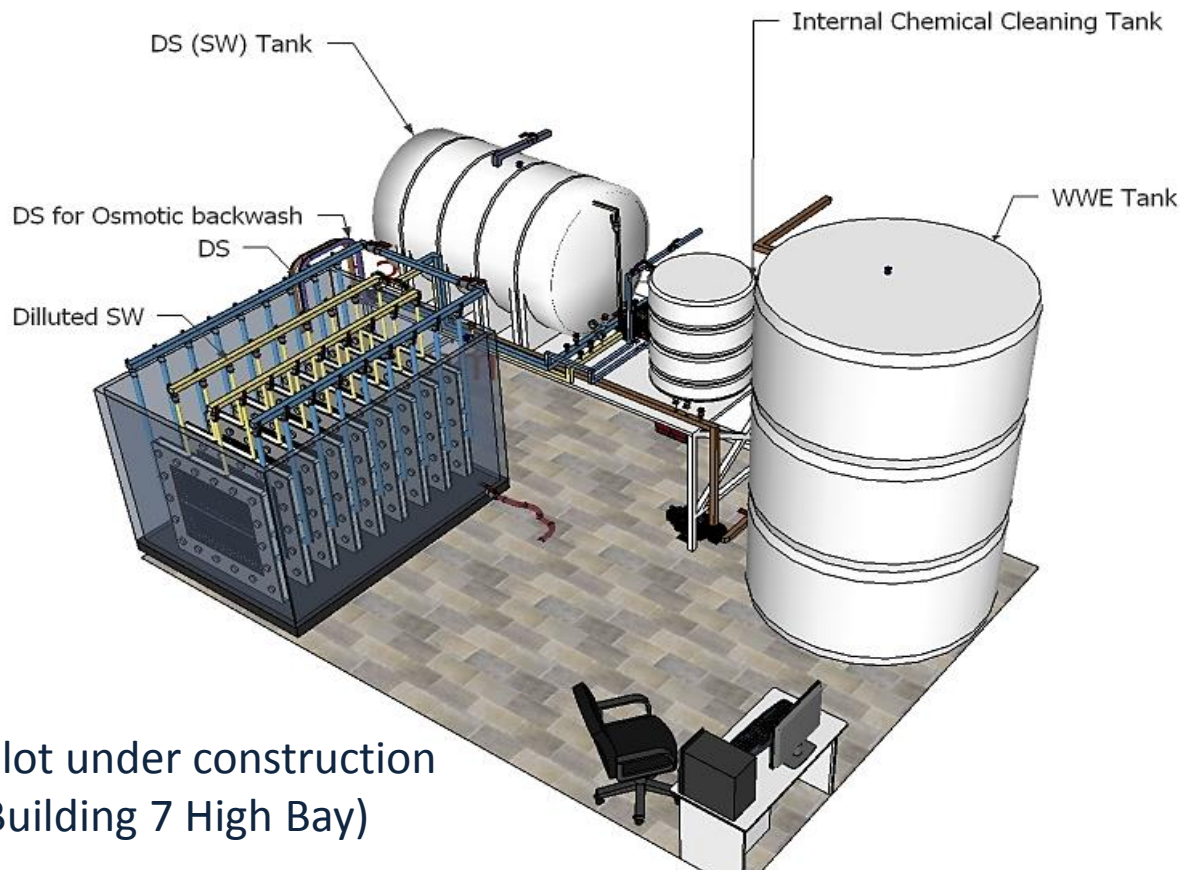
- **Three main research groups:**
 - Seawater and brackish water desalination group.*
 - Wastewater reclamation/reuse group*
 - Groundwater aquifer recharge and recovery group*



Water Desalination and Reuse Center



- Several new directions in low energy desalination
- Additional strength in water safety /microbiology
- Two new pilots under construction



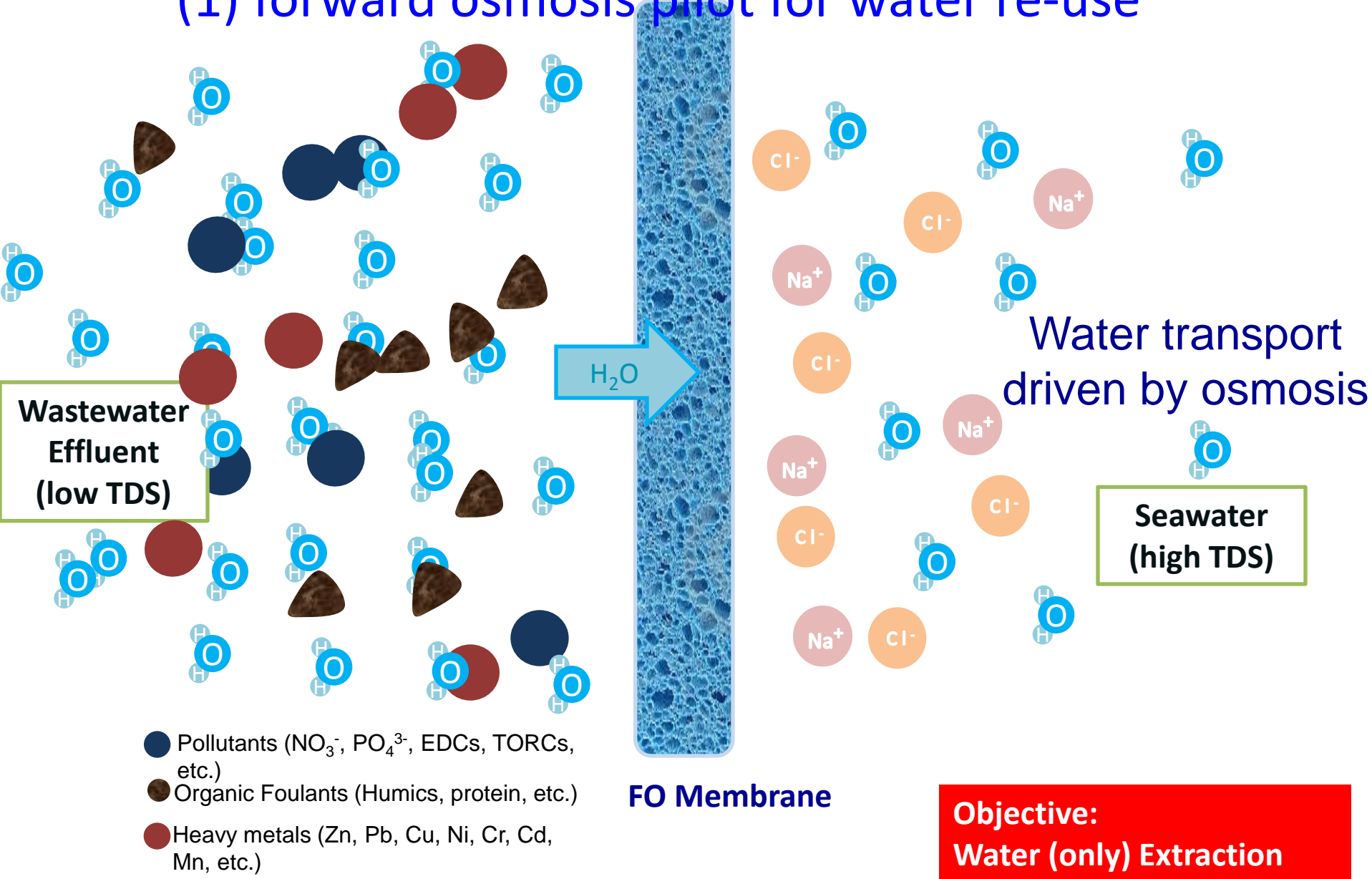
Forward Osmosis for
water-reuse



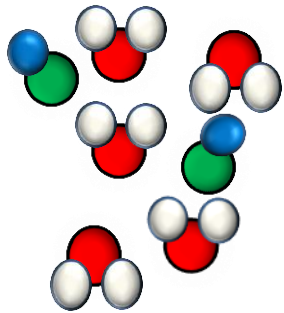
Pilot under construction
(Building 7 High Bay)

Examples of KAUST technologies:

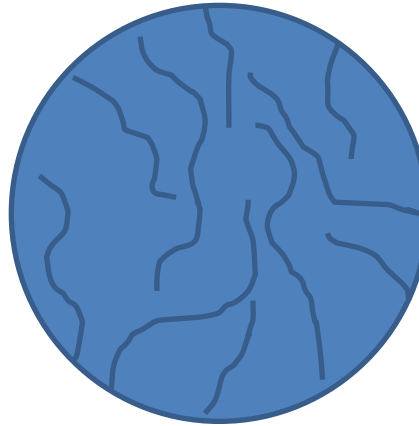
(1) forward osmosis pilot for water re-use



Adsorption-Desorption Desalination



Water Vaporization
(at the evaporator)
salt is left behind



Silica Beads

Adsorption → Desorption
Solar heat)

Condensed water Vapor (at
the Condenser)

- Solar energy or waste heat is used to desorb water
- The system produces two useful effects: **cooling and pure water** desalination only requires low temperature heat input ($\sim 65^{\circ}\text{C}$) from the sun or from a waste heat source.
- Low energy usage and no moving parts

Kim Choon NG and Gary AMY

Examples of KAUST technologies:

(2) Adsorption-desorption desalination (AD)



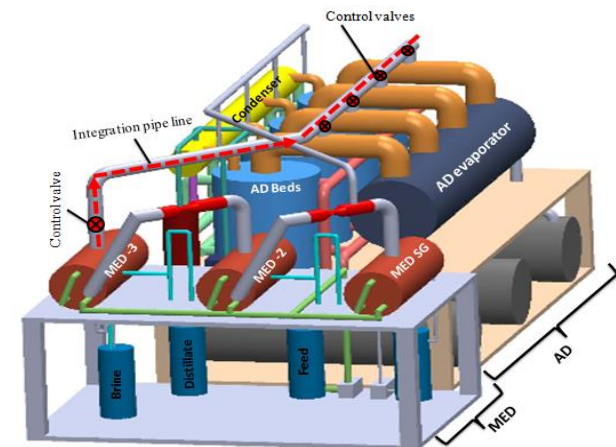
= Desalinated Water



KAUST Adsorption-Desorption desalination pilot

Process	kWh/m ³ *	US\$/m ³
Thermal	6 - 16	0.60-1.00
Membrane	3 - 6	0.45- 0.80
AD	1.4-1.9	0.29-0.30

* Total energy (includes thermal and electrical)

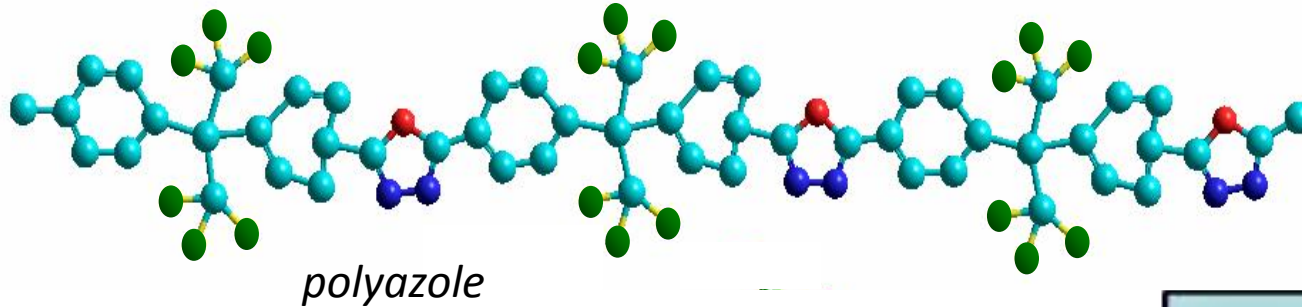


KAUST MED/AD pilot under construction

Novel membrane material for low-energy water purification: membrane distillation



Professor
Suzana Nunes

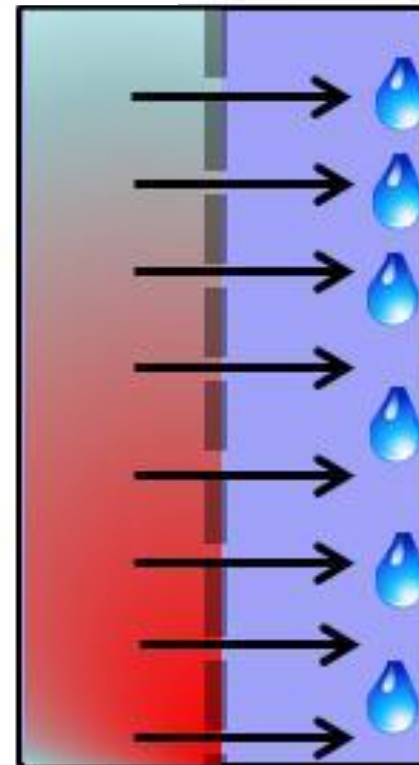


Membrane requirements:

- High hydrophobicity (*high contact angle non-wetting surface*)
- High thermal stability
- Low thermal conductivity
- High porosity
- Chemical stability
- Processability

Feed Solution

(Heated)



Distillate
(cold)

H. Maab, L. Francis, A. Al-saadi, C. Aubry, N. Ghaffour, G. L. Amy and S. P. Nunes, J. Membrane Sci. 2012

Driving force is the difference in partial pressure

Bill Gates, world-renowned technology pioneer, visited KAUST on Tuesday, June 24, 2014

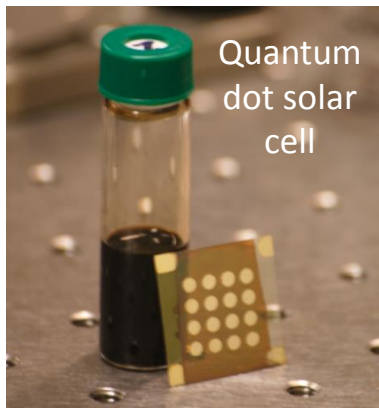


More in WDRC Newsletter!

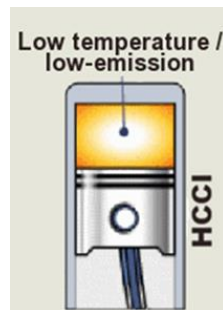
The KAUST Energy Thrust

The KAUST Energy Thrust pervades our three Divisions and five of our nine Research Centers:

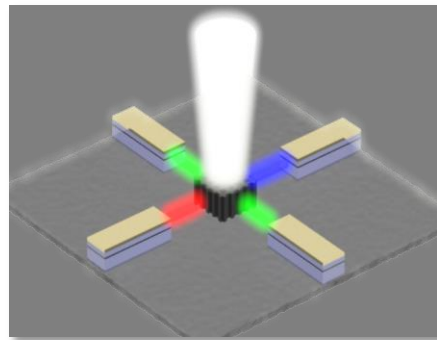
- Clean Combustion Research Center
- Solar Photovoltaic Engineering Research Center
- Catalysis Research Center
- Water Desalination and Reuse Center
- Membrane and Porous Materials Research Center



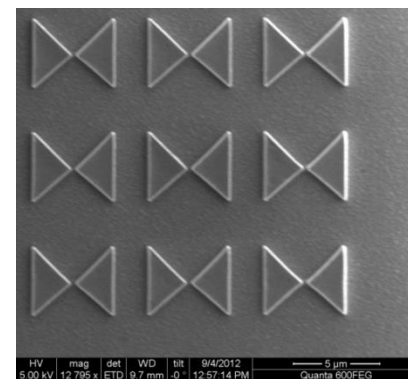
Efficient
photovoltaic cells



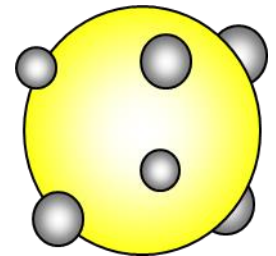
Cleaner
burning
fuels



Laser solid-state
lighting



Rectifying nano-
antennae



Catalysts for
solar hydrogen
production

The KAUST Food Thrust

The KAUST Food Thrust is largely within the Division of Biological Sciences and Engineering with much activity in the Center for Desert Agriculture.



**Can food be grown
in the desert**



The KAUST Environment Thrust

Involving all of our Academic Divisions, this Thrust is perhaps best exemplified by the Red Sea Research Center.

Develop a scientific basis for the preservation of the unique environment of the Red Sea, enabling the safe and productive exploitation of its resources.

- **Environmental sustainability**
- Sensor networks
- Wind, current patterns
- **Coral, fish**
- Extremophiles, natural products
- **Molecular Genomics**



Prof. Michael Berumen tagging Red Sea Whale Shark



THANK YOU!