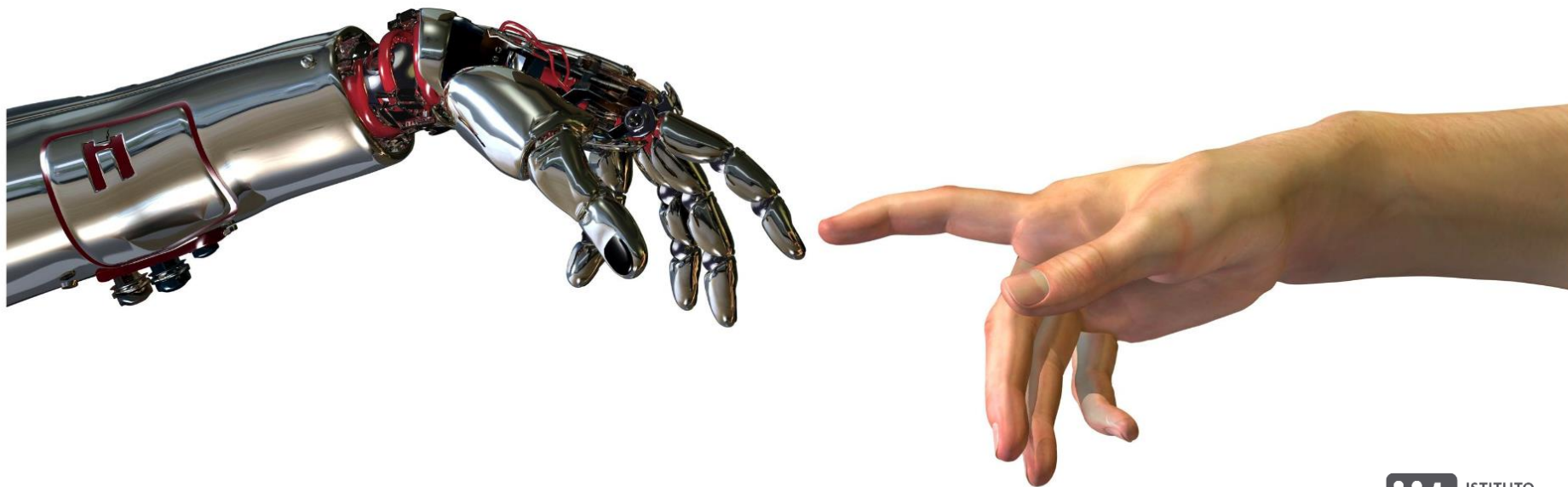


## Trends in sustainable technologies

*Guglielmo Lanzani*

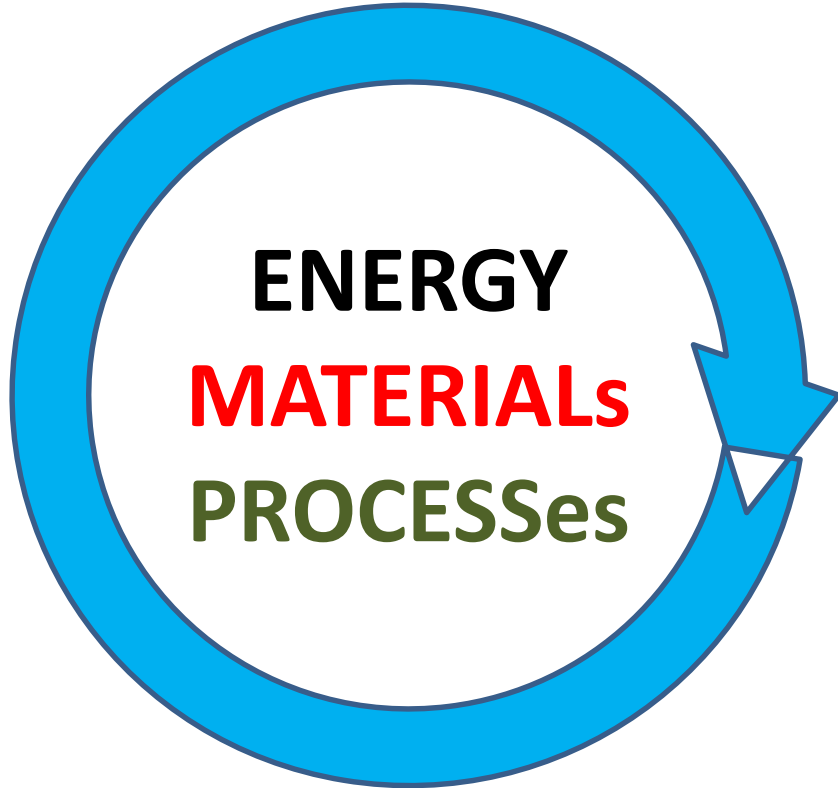
*Head of the Center for Nano Science and Technology of the Italian  
Institute of Technology, Professor in Physics - Politecnico University of  
Milan*

# Innovation for sustainable development



Guglielmo Lanzani, Istituto Italiano di Tecnologia – Politecnico di Milano







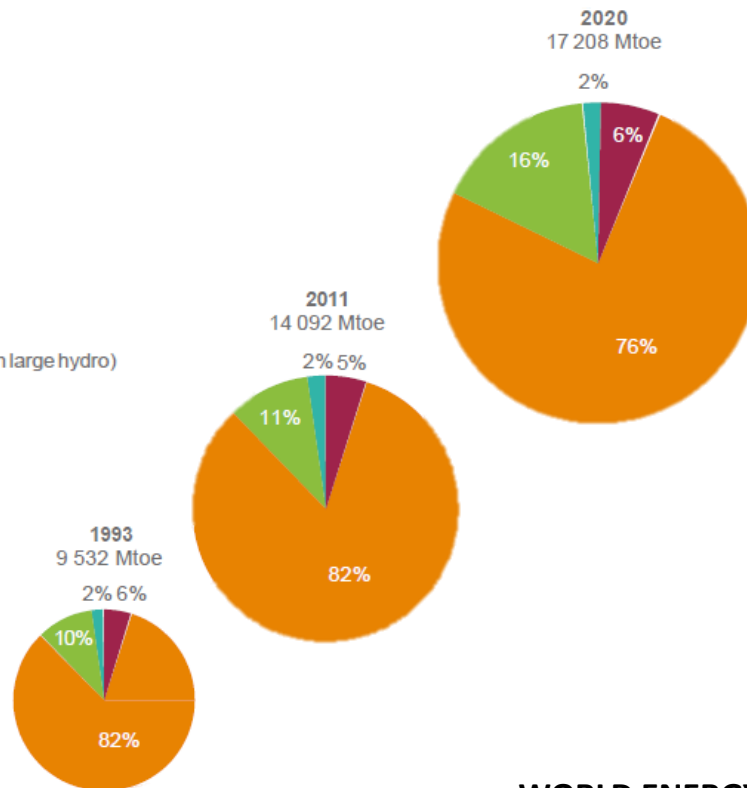
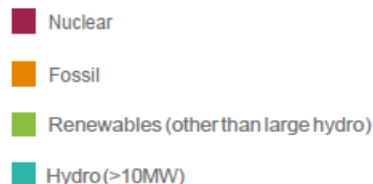
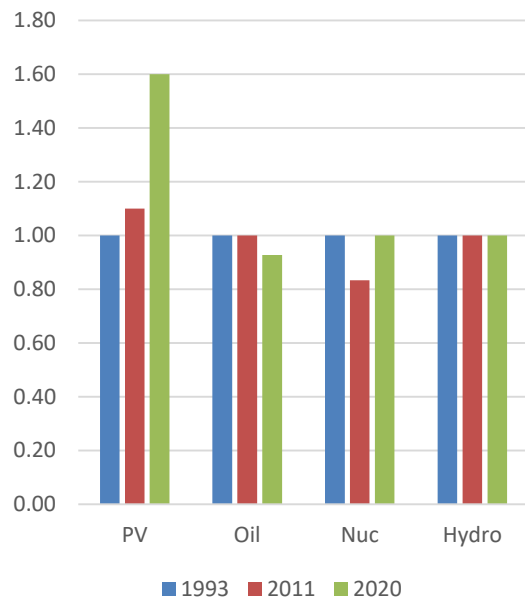
World energy is constant  
World entropy is increasing

Claudius. *Annalen der Physik und Chemie.*, Vol. 125 No. 7 (1865): 353–400.

## Total Primary Energy Supply by resource 1993, 2011 and 2020

**Source:** WEC Survey of Energy Resources 1995, World Energy Resources 2013 and WEC World Energy Scenarios to 2050

### Growth rate



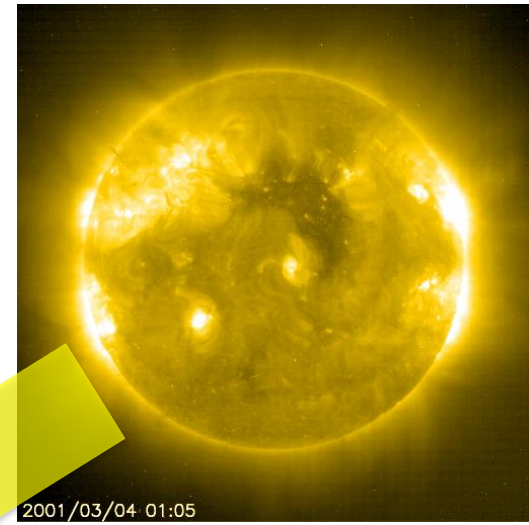


The Stone Age didn't end because we ran out of stones



\*Former Saudi oil minister, Sheik Ahmed Zaki Yamani

**170000 TW**



*2009 (6.5 Billion people) 12 TW*

*2050 (8-10 billion people) 20 TW*

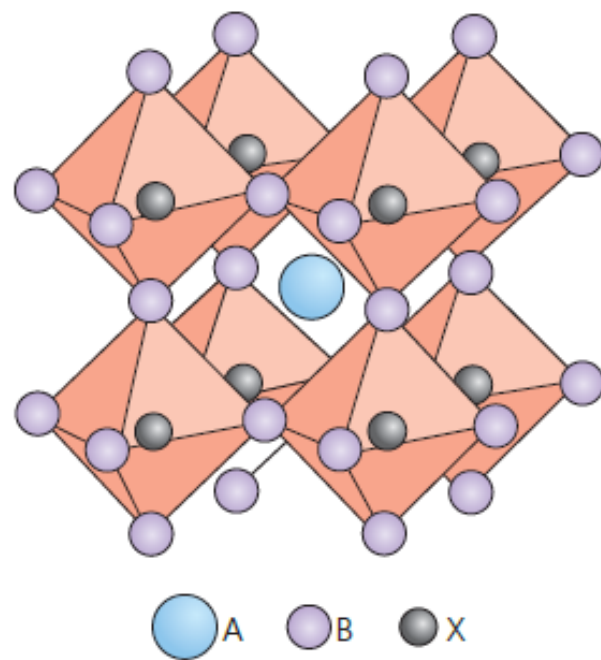
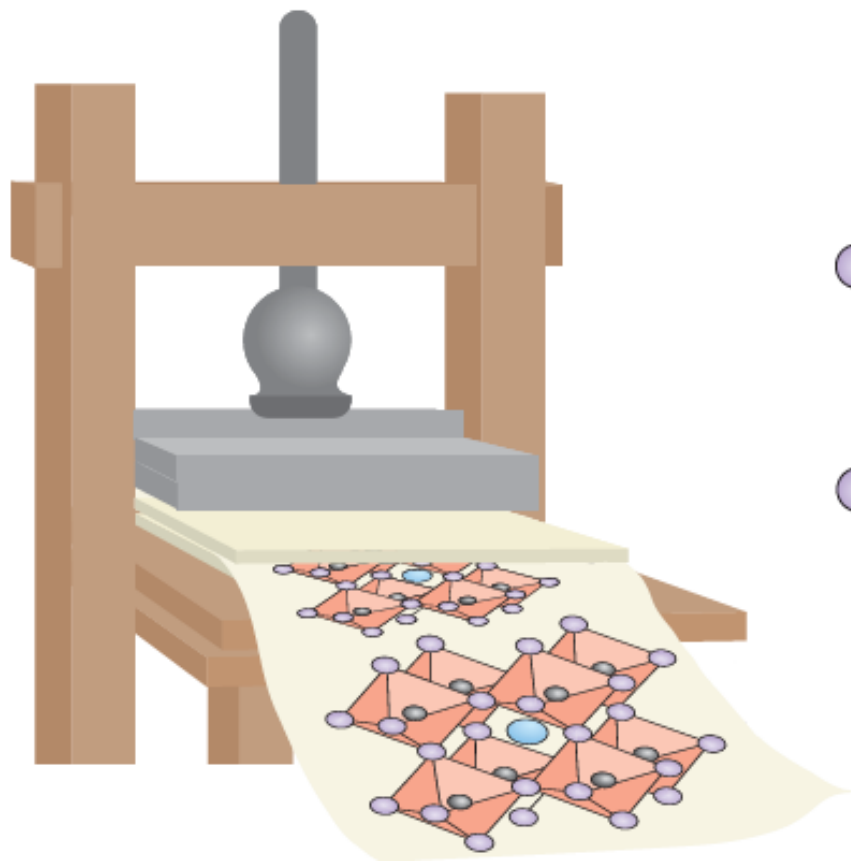


(10 km sq) in Kamuthi in the state of Tamil Nadu (India)

648 MW



230 gigawatt worldwide in 2015



# Energy Everywhere

Affordable electrical power available to everyone **everywhere**.

## Locally Manufactured



## Locally Consumed



# Energy Everywhere

Providing Energy at the Point of Consumption, for Everyone, Everywhere



Flexible,  
lightweight  
**perovskite**  
**modules** bring  
power to areas  
where the power  
network is weak  
or non-existent.



Building  
Integrated



Agriculture



Transportation



Over Water



Lighting



Emergency  
Power



Personal  
Electronics

## Market opportunity for indoor photovoltaics



Wireless charger for the Internet of Things

Home/Building automation

iBeacon/Beacon

Electronic Shelf Labels



Billions of objects connected in a network all have one common need:  
**energy independence**

> Recyclable

> Flexible

> Printed

> Customized

> Thin (>0.1 mm)

> Lightweight ( $\approx 100 \text{ g/m}^2$ )

> Highest W/g



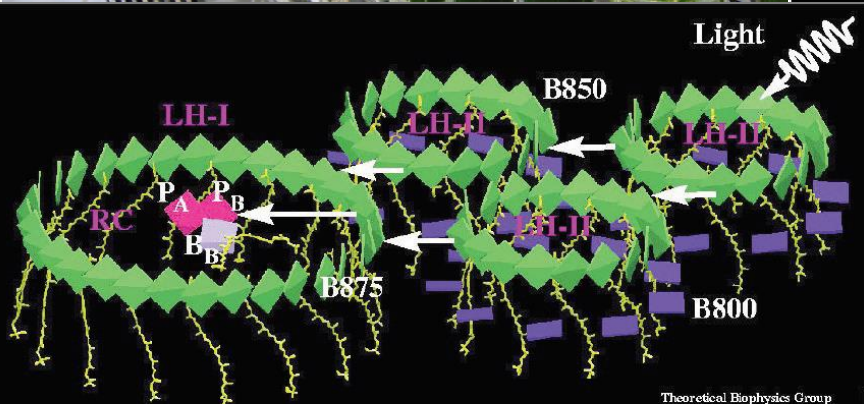
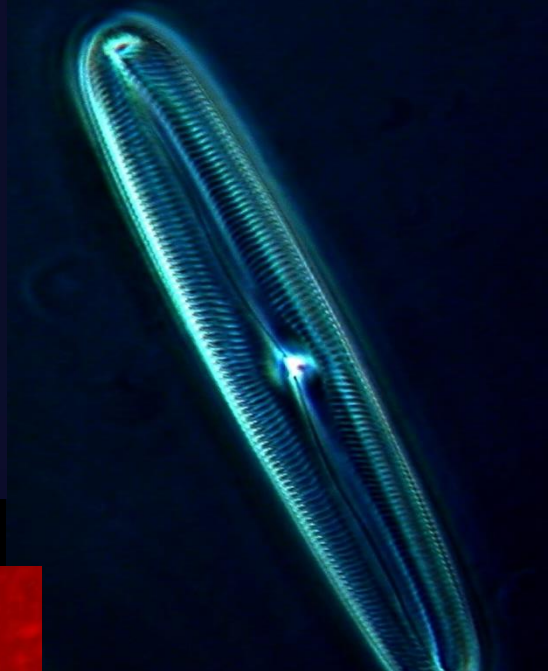
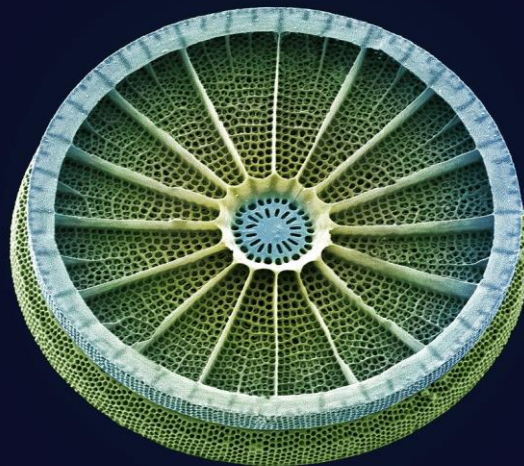
# 100 TW

115 × 10<sup>6</sup> tons di carbonio atmosferico

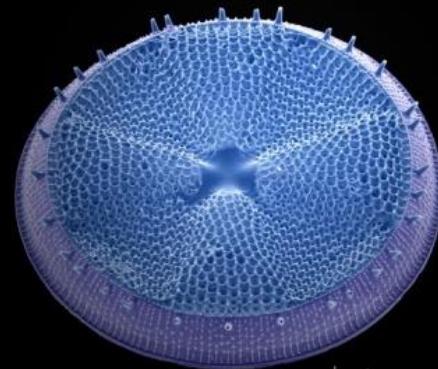
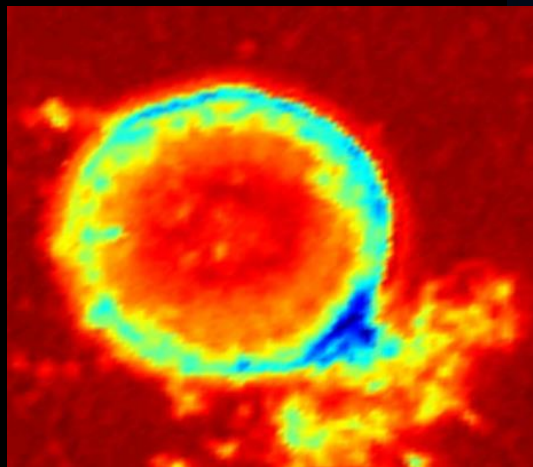


**BIOMASS**





Theoretical Biophysics Group  
 Beckman Institute  
 University of Illinois Urbana-Champaign



SCIENCEPHOTOLIBRARY

# New Energy Sources

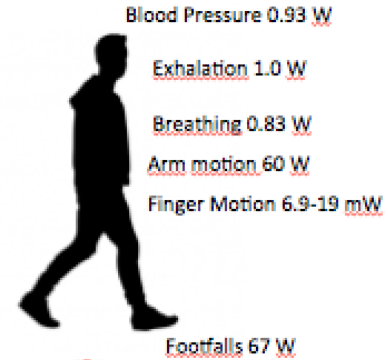
## VIBRATIONS



## FLUID FLOW

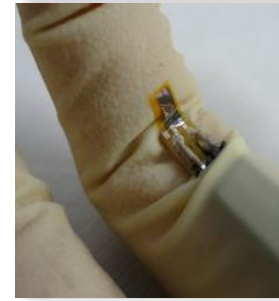
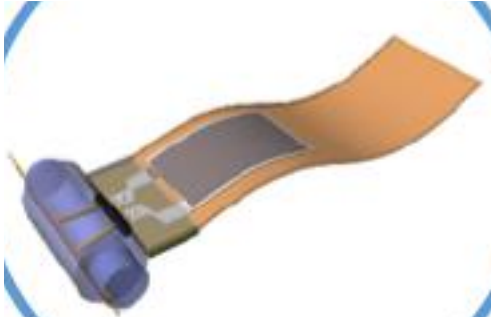


## BIOMECHANICS





# Soft Piezoelectrics: Energy harvesting



1<sup>st</sup> gen:  $\sim 0.26 \text{ mW/cm}^3$ , cut-in wind speed =  $0.1 \text{ m/s}$

$10 \text{ W/m}^2$

S. Petroni et al. "Flexible AIN flags for efficient wind energy harvesting at ultralow cut-in wind speed," RSC Adv., 2015

# FLEXIBLE PIEZOELECTRICS FOR THE BODY and for PROSTHETICS

## SMART PATCHES

Physical and Biochemical sensors

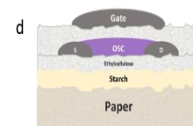


## ELECTRONIC TATOOS

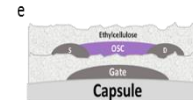
Piezoelectric sensors (pressure, temperature, biomotility ...)



## EDIBLE ELECTRONICS



Before transfer

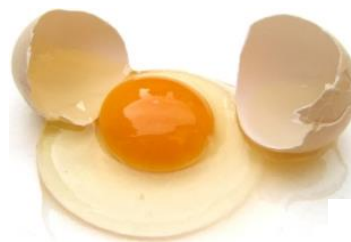


After transfer

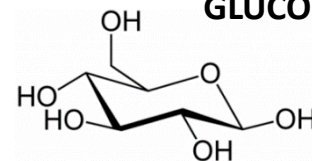




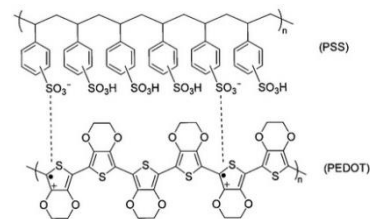
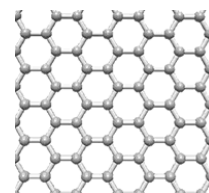
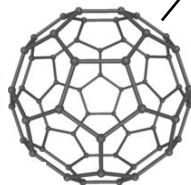
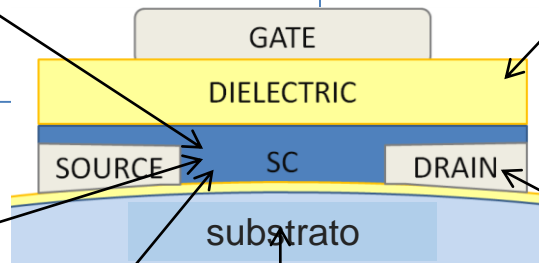
**ALBUMINA**



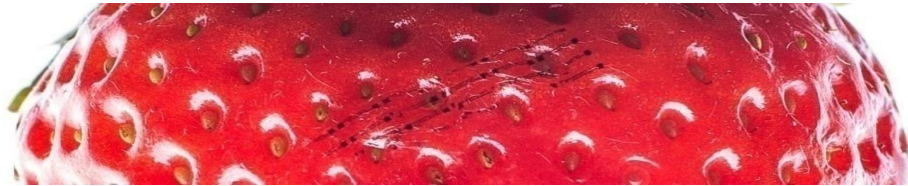
**GLUCOSIO**



**INDIGO**







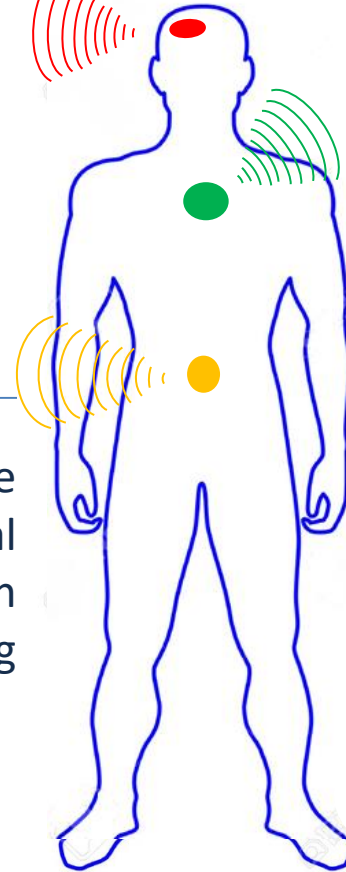
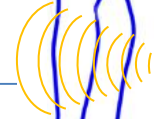
Brain  
monitoring



Esophagus pH  
monitoring



Intestine  
Microbial  
Population  
monitoring

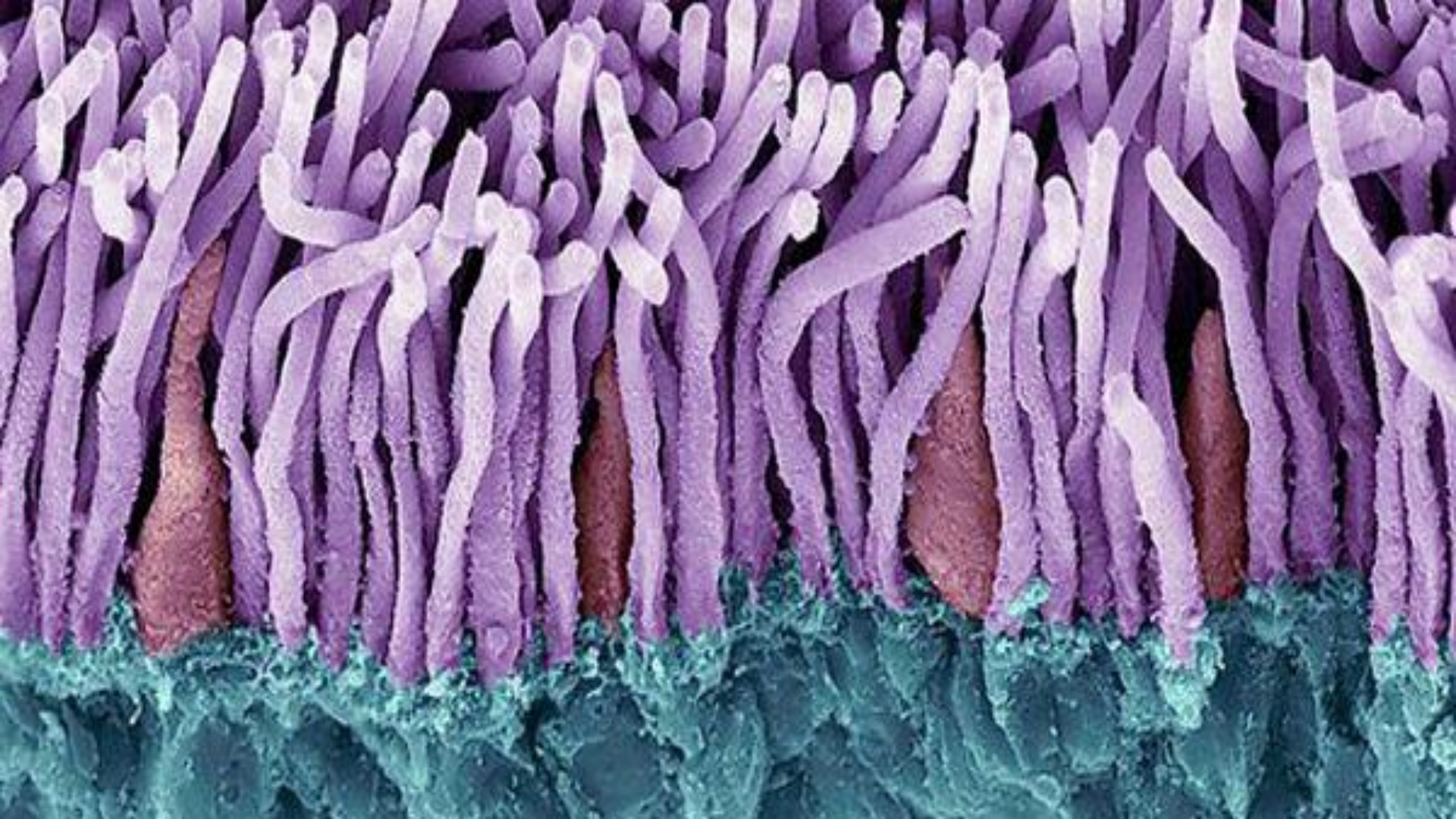






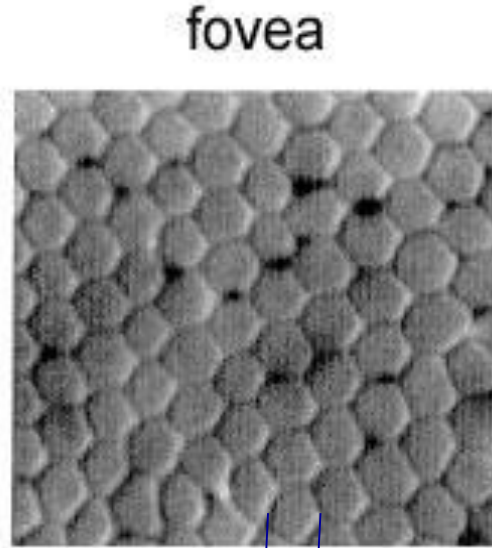
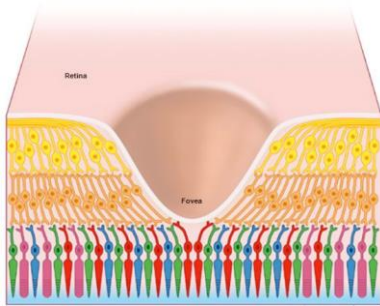
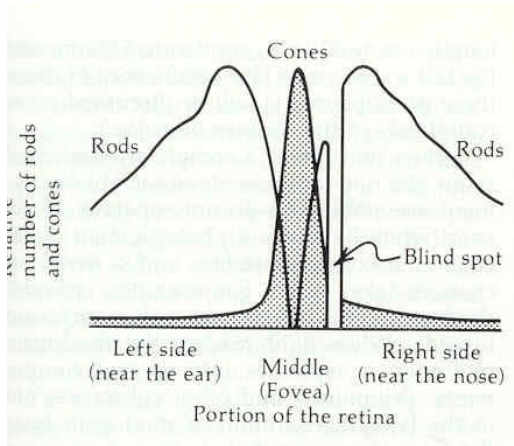




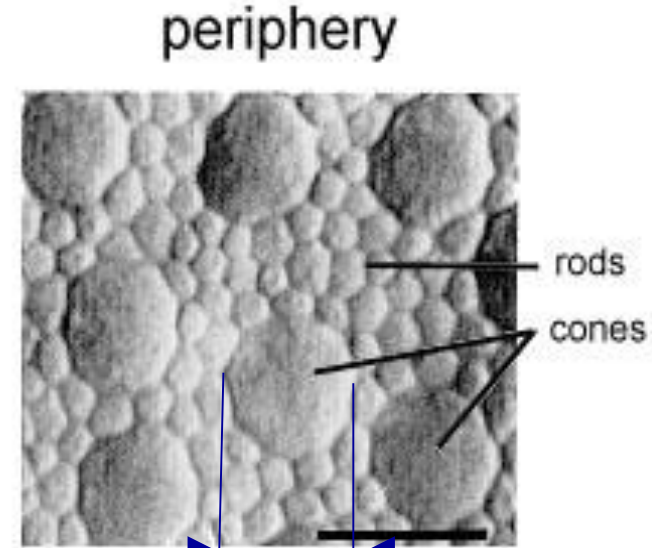


# Photoreceptors Spatial distribution

120 million rods and few million cones



2.3 micron

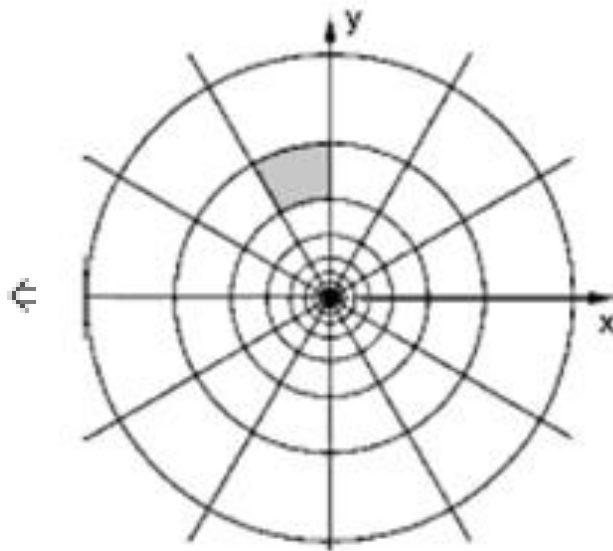


10 micron

# How the brain perceives the world



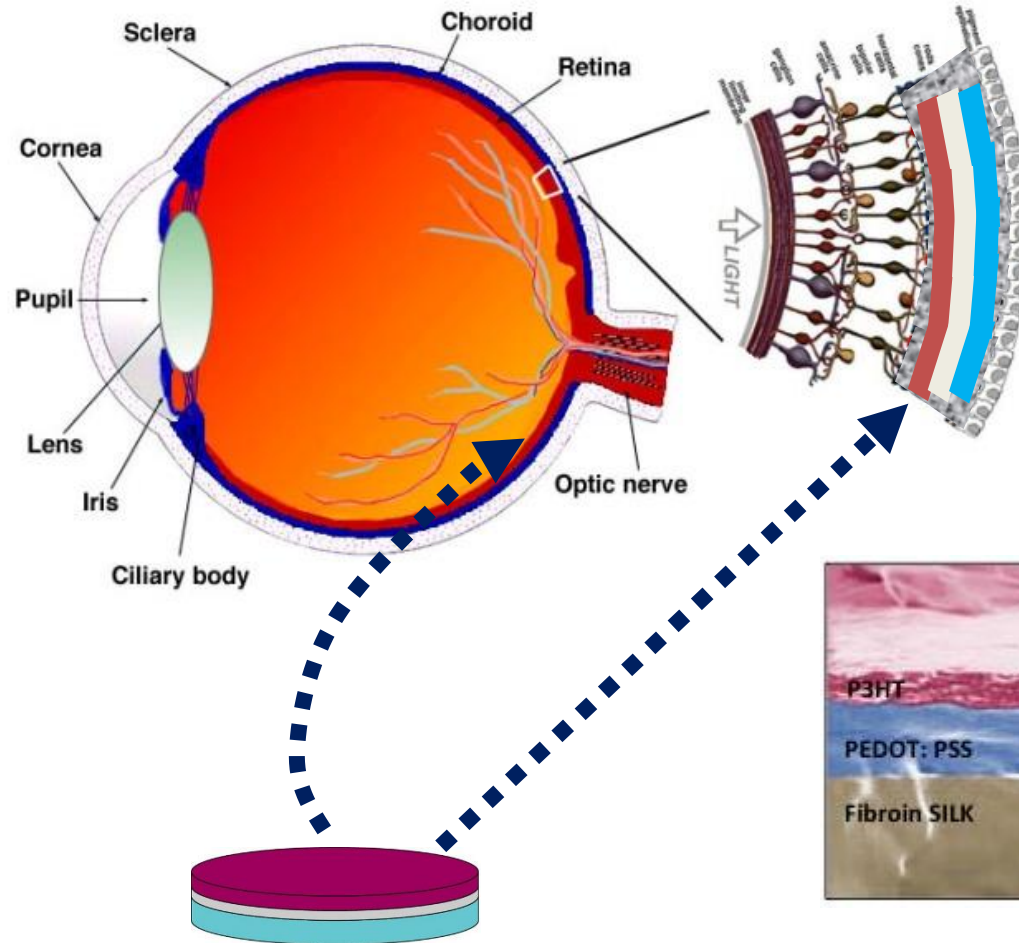
(a)



(b)

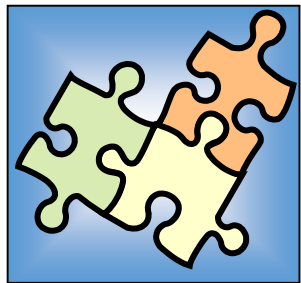




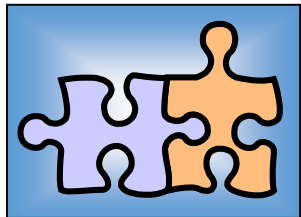


*Nature Materials*. **16**, 681 (2017) *Adv. Healthcare Mater.* **5**, 2271 (2016)

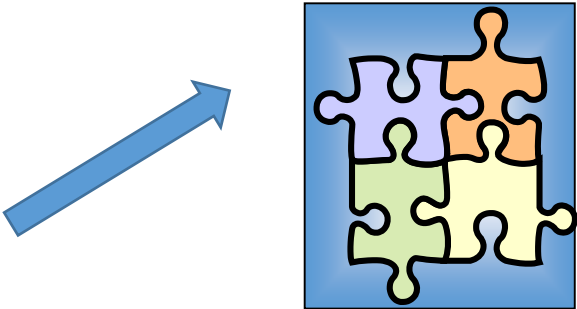
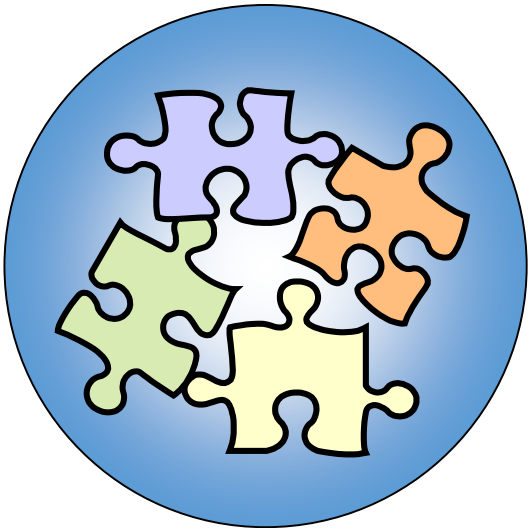
# Biochemical robots



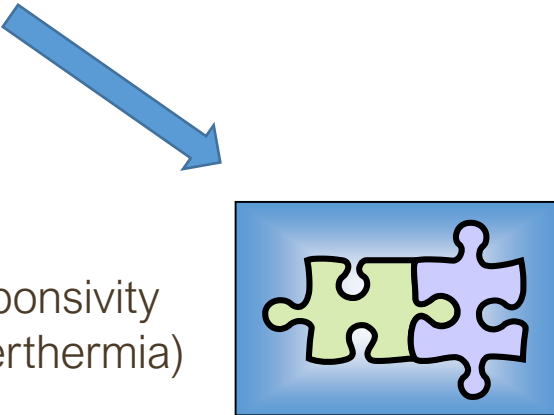
Imaging  
(Fluorescence NMR)



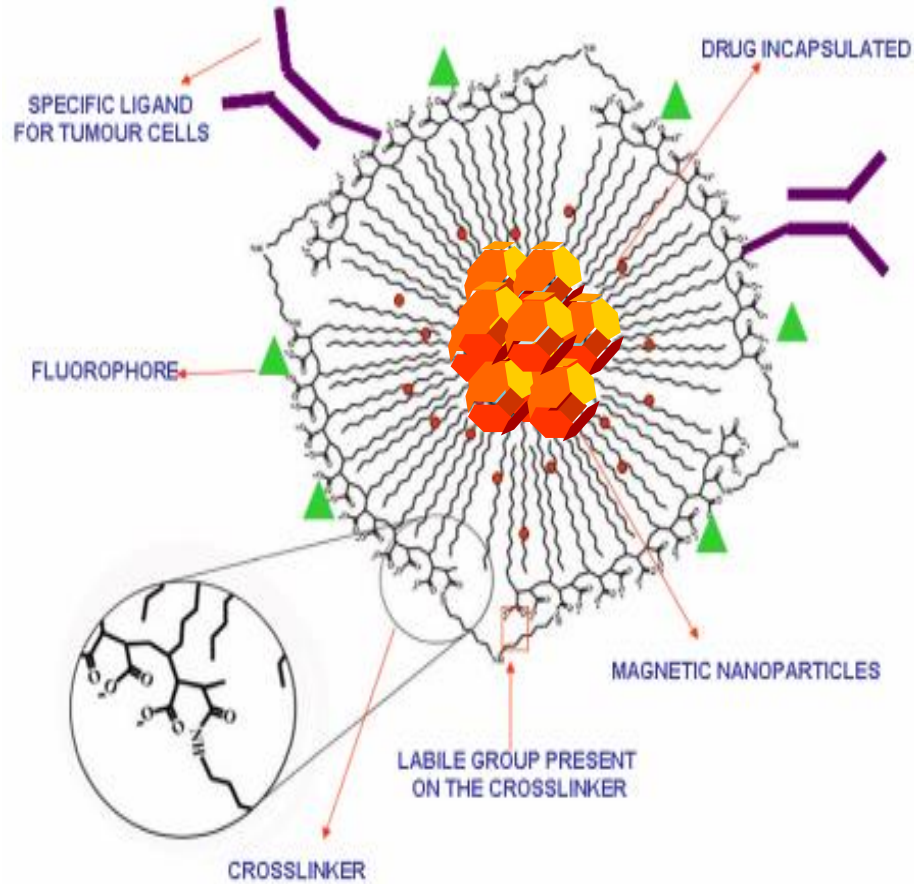
Sensing  
(Ph, T, EF,  
Biochemistry)



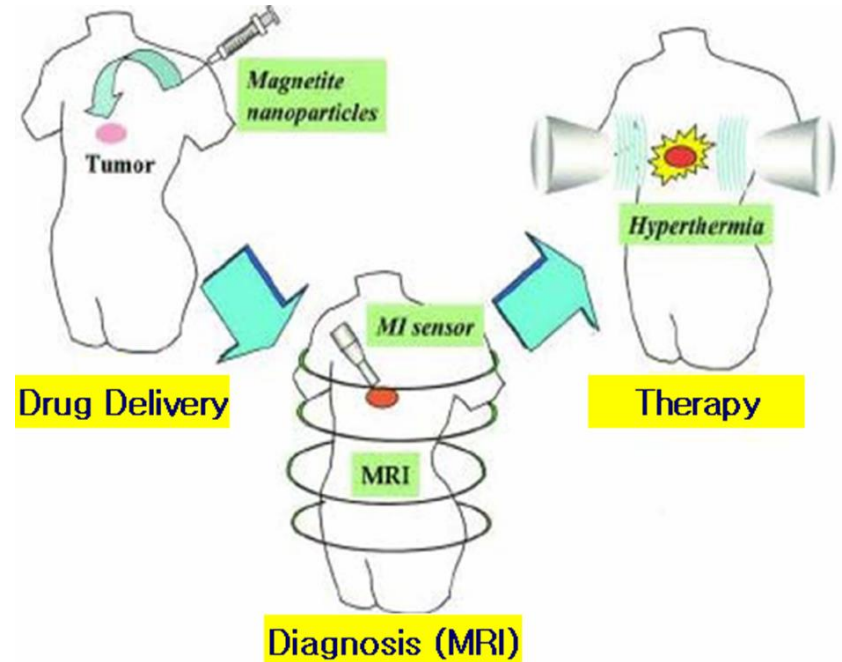
Actuation  
(Drug Delivery)



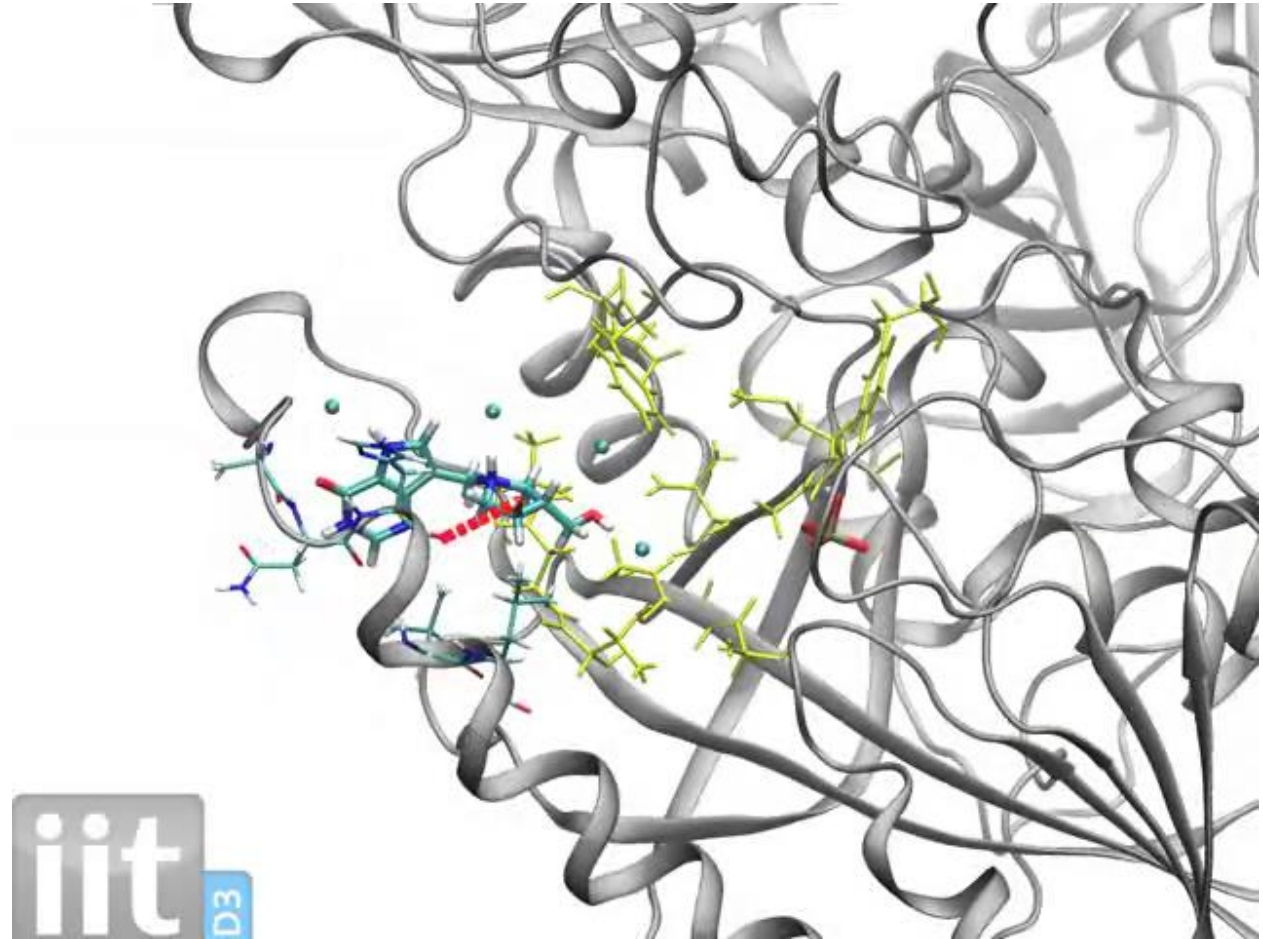
Responsivity  
(Hyperthermia)



## Artificial antibodies



# Drug Discovery

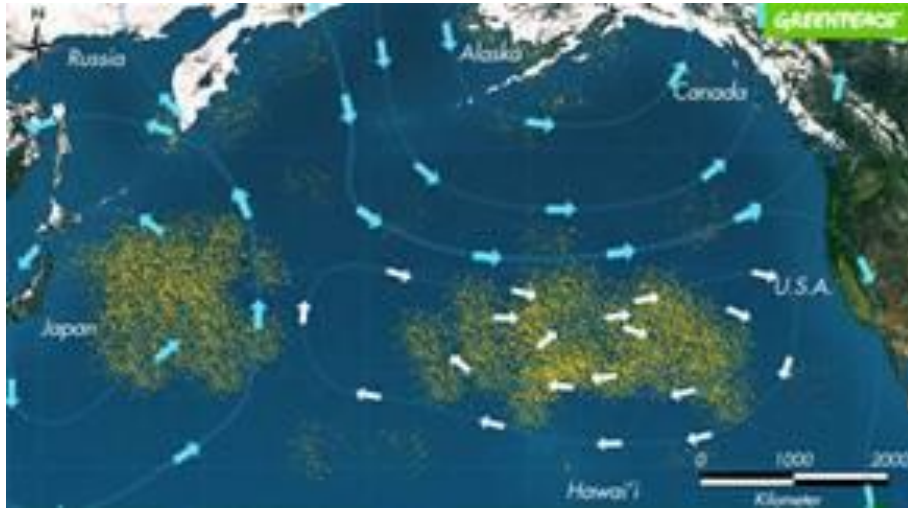






Environment

# Plastic floating islands: 290 millions tons of plastic every year

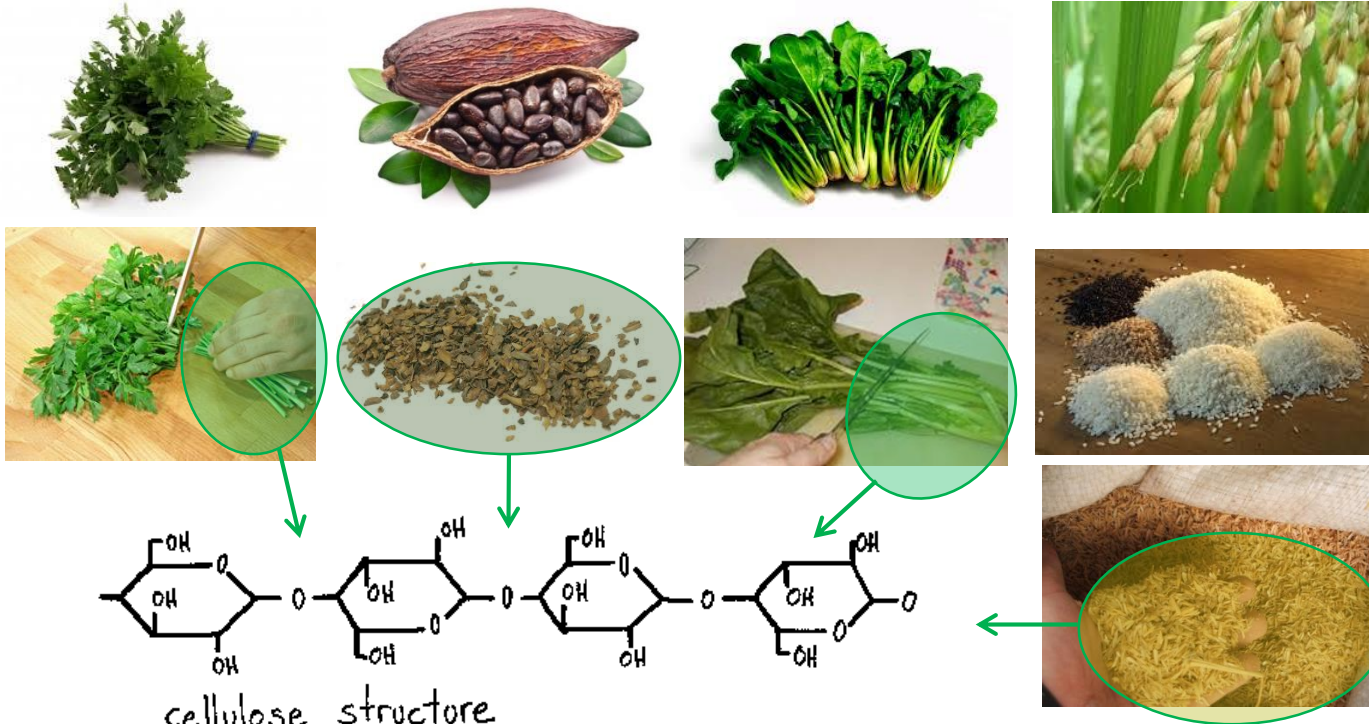


Can we get rid of plastic?

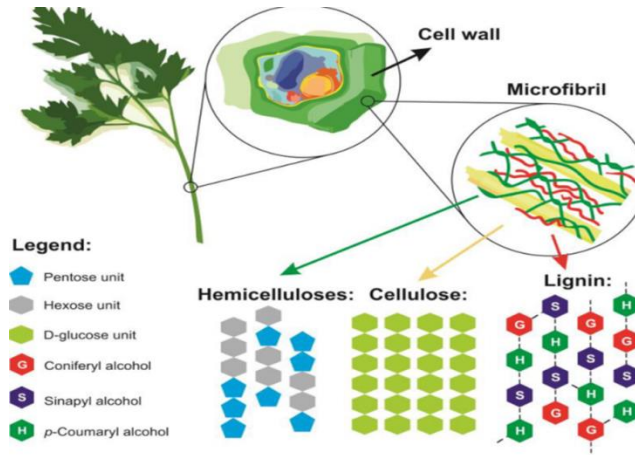
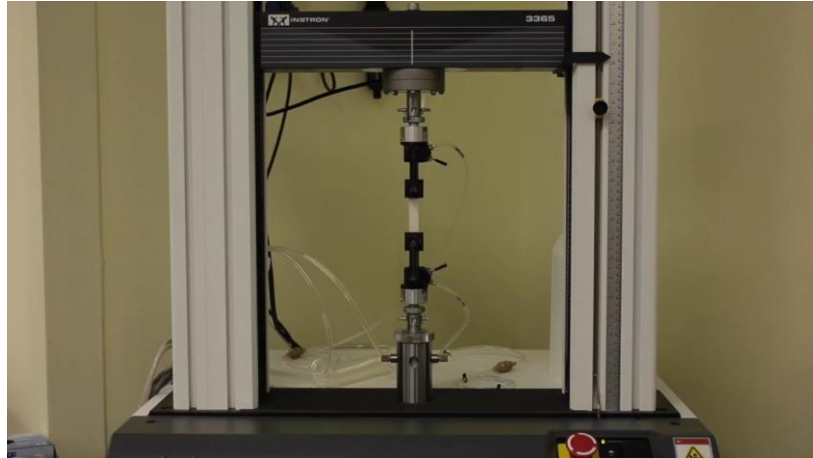
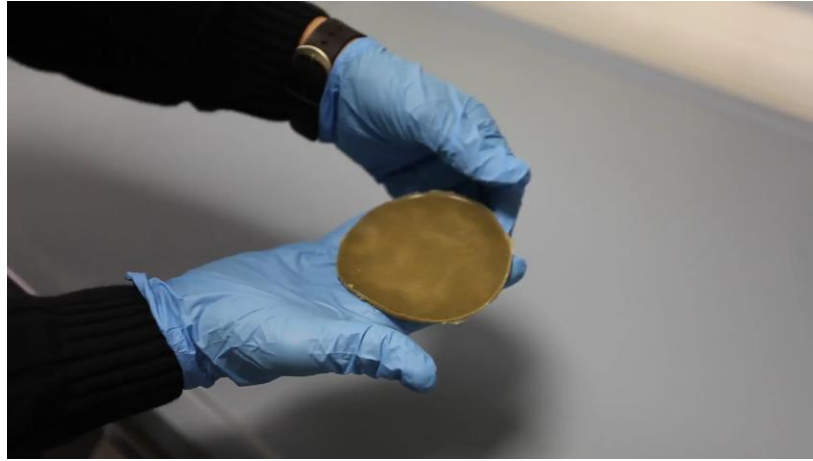


# New Biopolymers

Wastes from edible vegetables in Europe:  
28 million tonnes of processed vegetable wastes every year

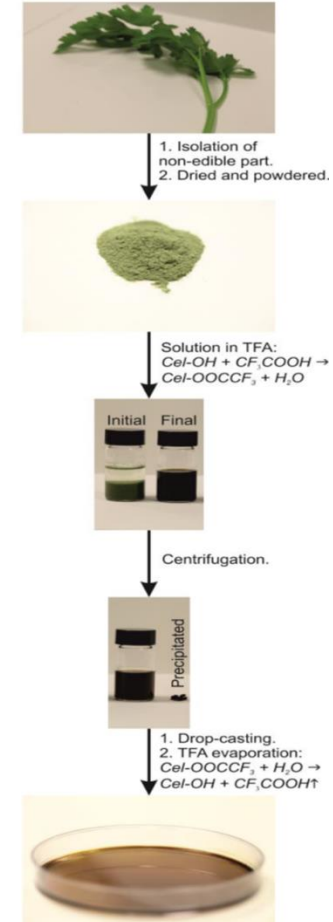


# Future: New soft, biodegradable plastics





**c**


Waste material	Biocoating	Bioplastic



# Project with Mercato Ortofrutticolo


 **SGM**  
società gestione mercato

 **iit** ISTITUTO ITALIANO DI TECNOLOGIA

 **ASCOM**  
L'UNIONE FA LA FORZA

## THE NEW LIFE OF FRUITS AND VEGETABLES


### BIOPLASTICS PACKAGING AND CIRCULAR ECONOMY




*live event*

ON THURSDAY 8TH FEBRUARY AT 3.30 PM  
AT FRUIT LOGISTICA HALL 2.2 STAND A07

IN COLLABORATION WITH

 **Comune di Genova**

 **Camera di Commercio Genova**





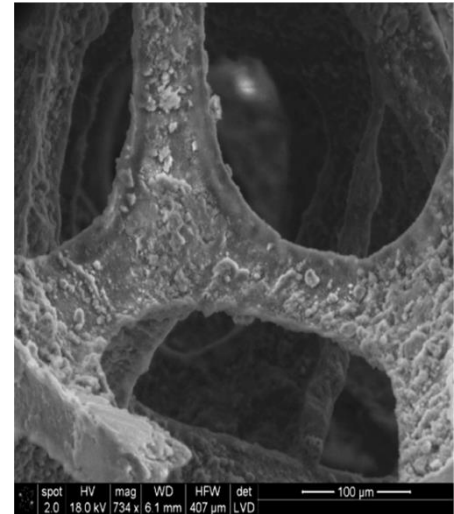
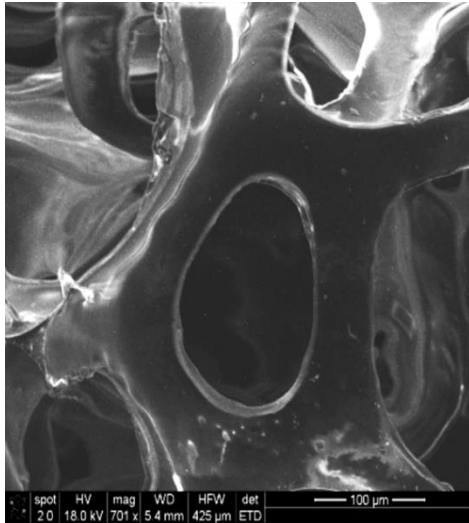
## Una soluzione semplice per problem complessi

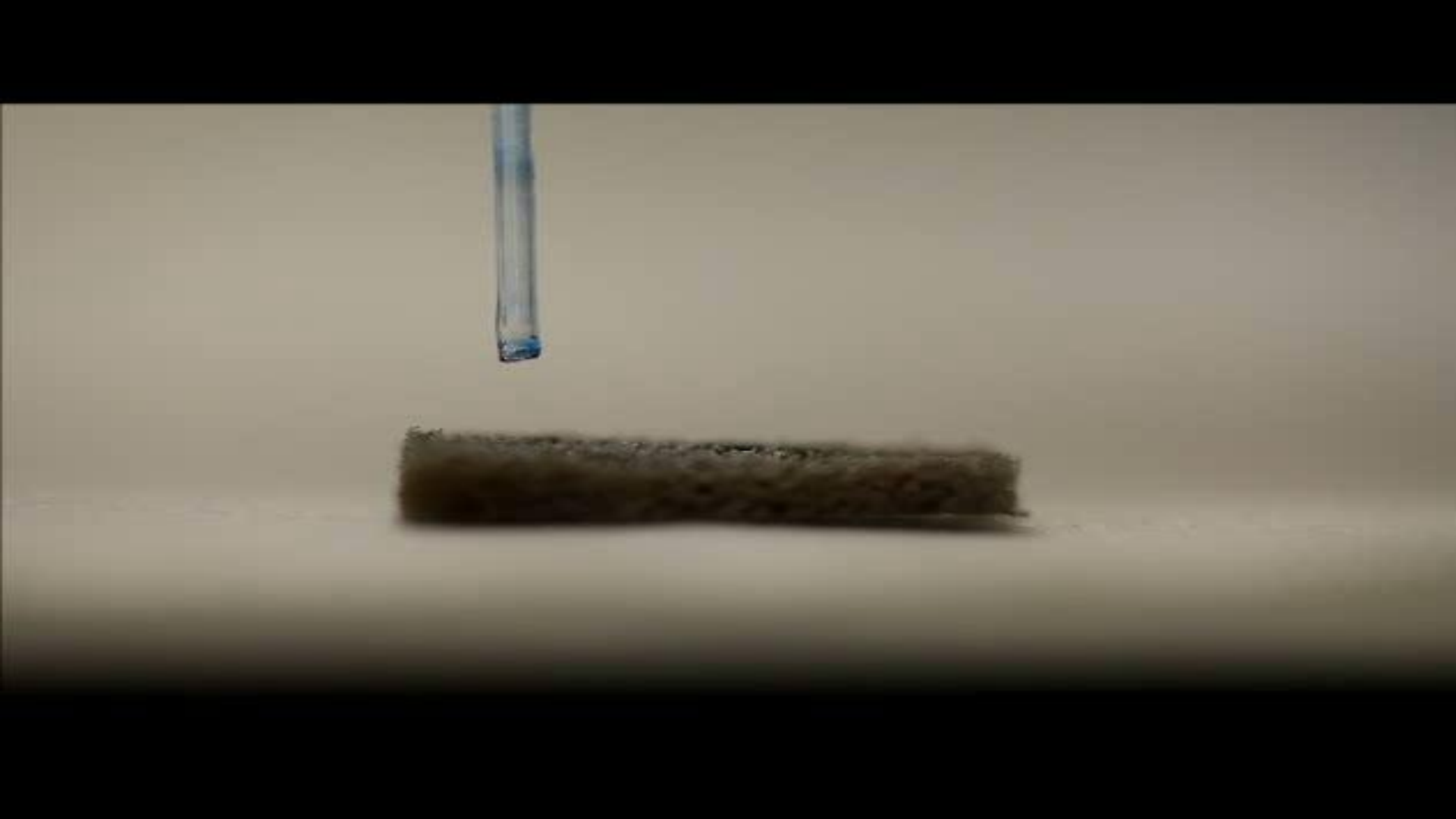






# SMART SPONGES



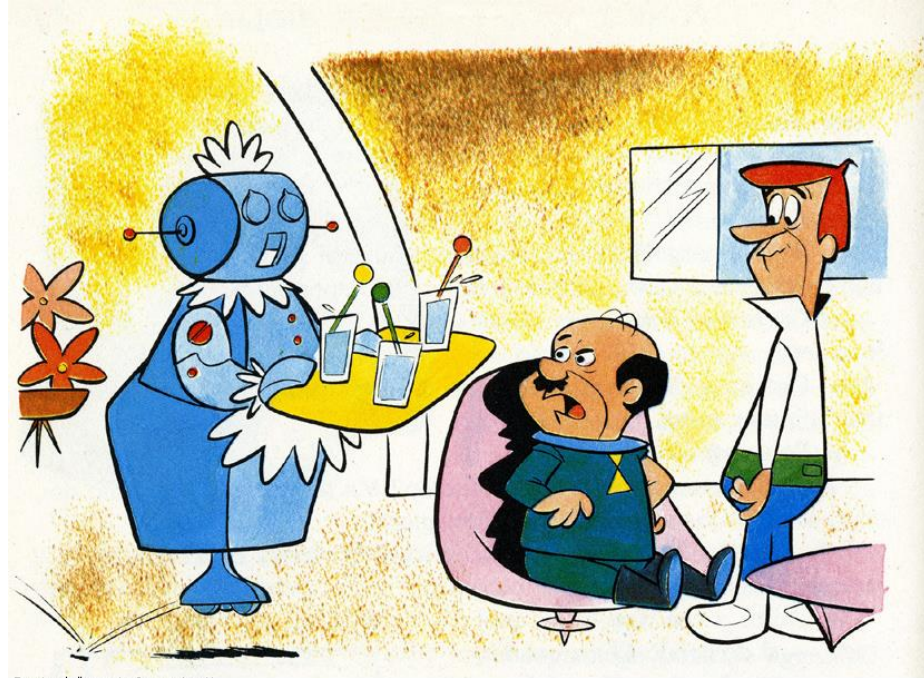


# Will Robots save us?

**2060**

over 65y età 33% (ora 18%)

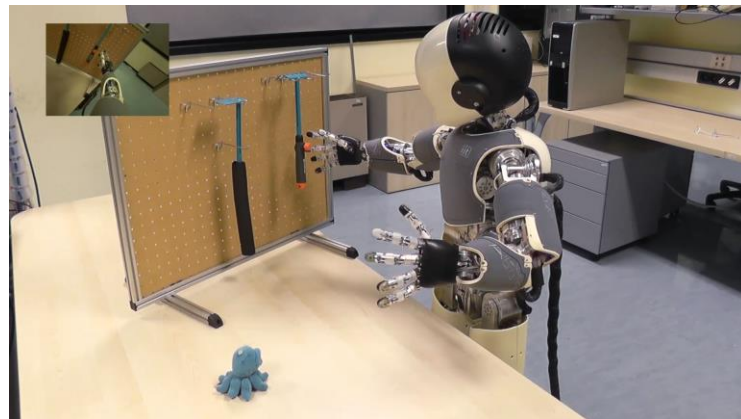
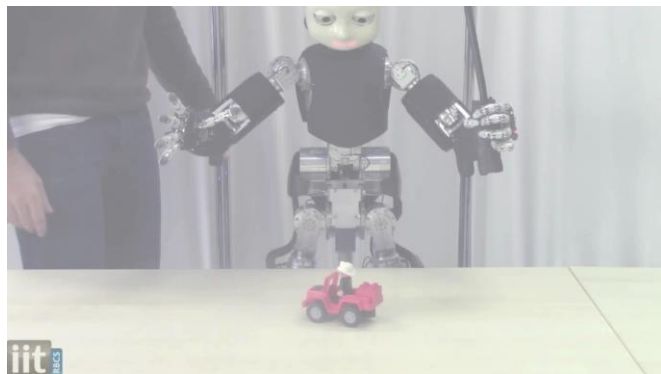
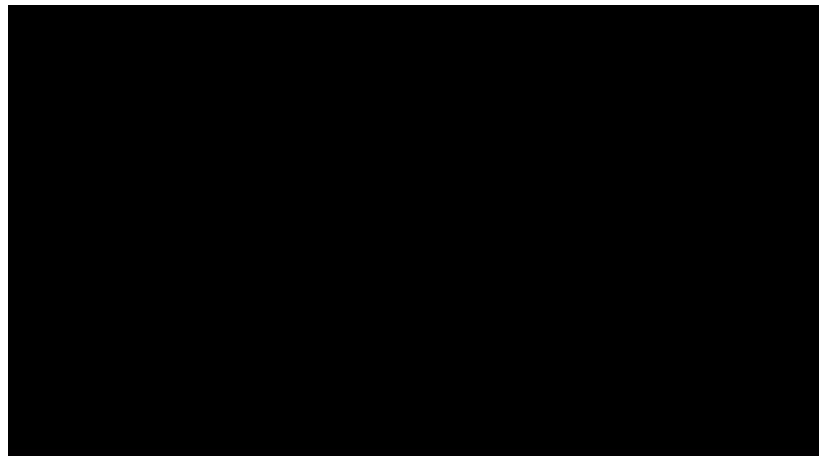
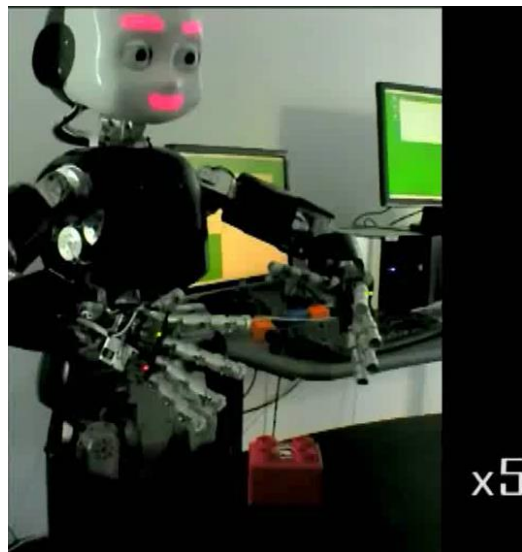
Pensionati > 50% (ora 26%)



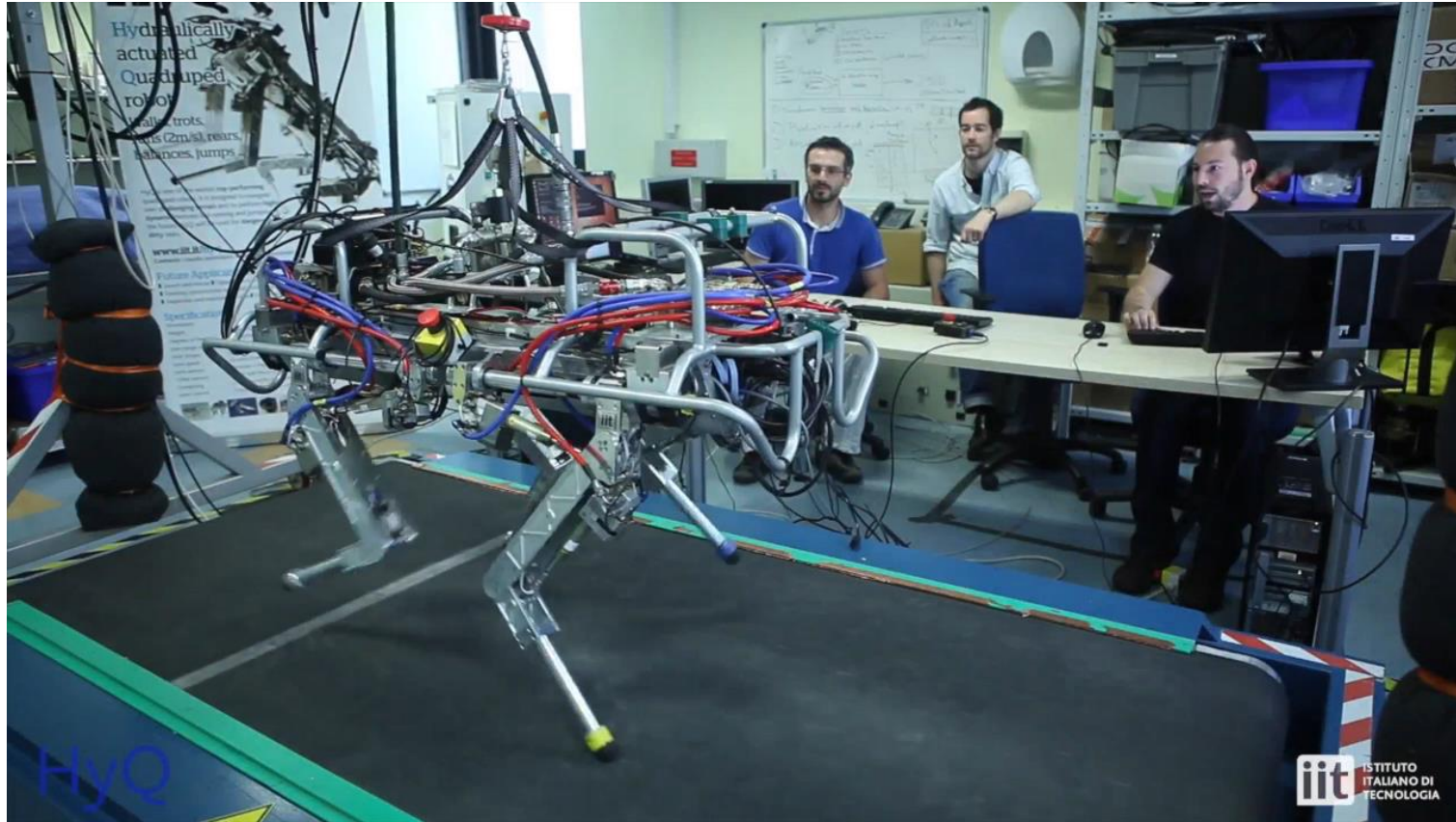
Rosie della serie I pronipoti







# HyQ hydraulic quadrupede Robot Quadrupede



HyQ



Plant-Inspired Robot



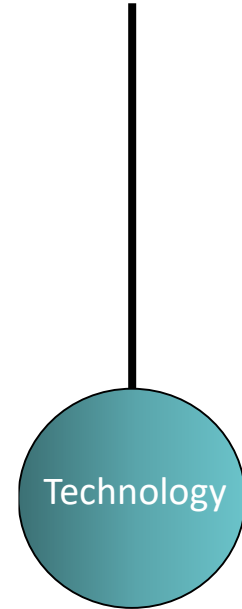
Plantoid







## Development pendulum (*from “The Economist”*)



Thank you for  
your attention

