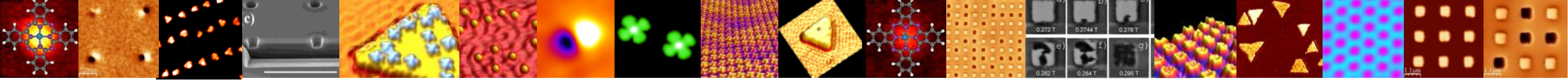


Nanoscience,

Atomic Force Microscopy,

& other topics at IPCMS

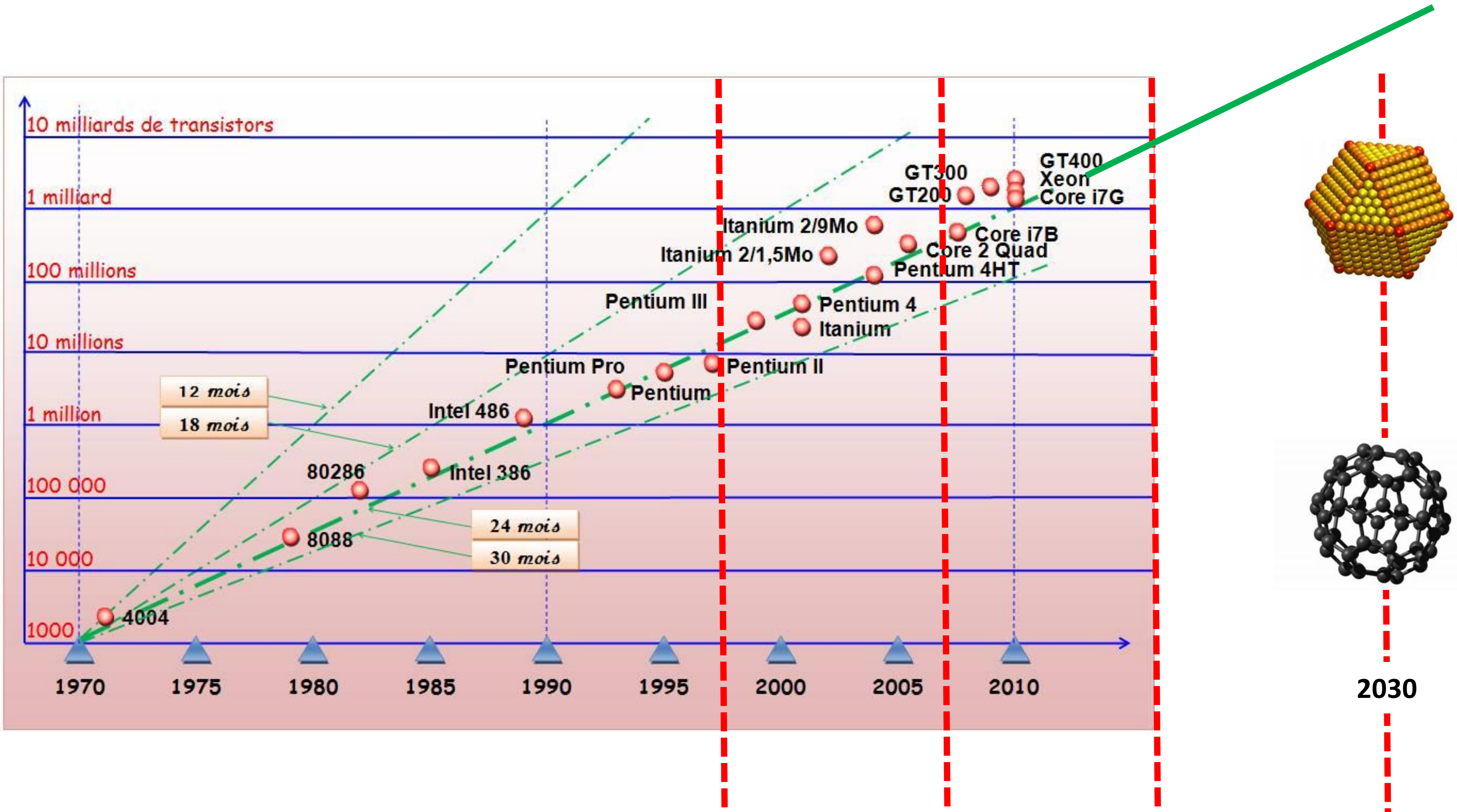
UNIVERSITÉ DE STRASBOURG

cnrs

rastei@ipcms.unistra.fr, Strasbourg 20.01.2017

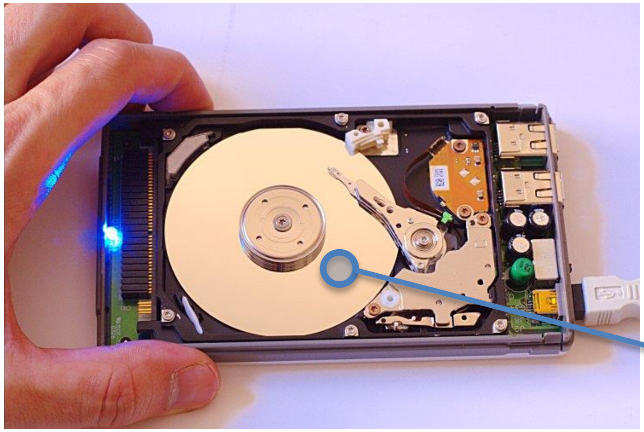
Why « nano » ? : data processing

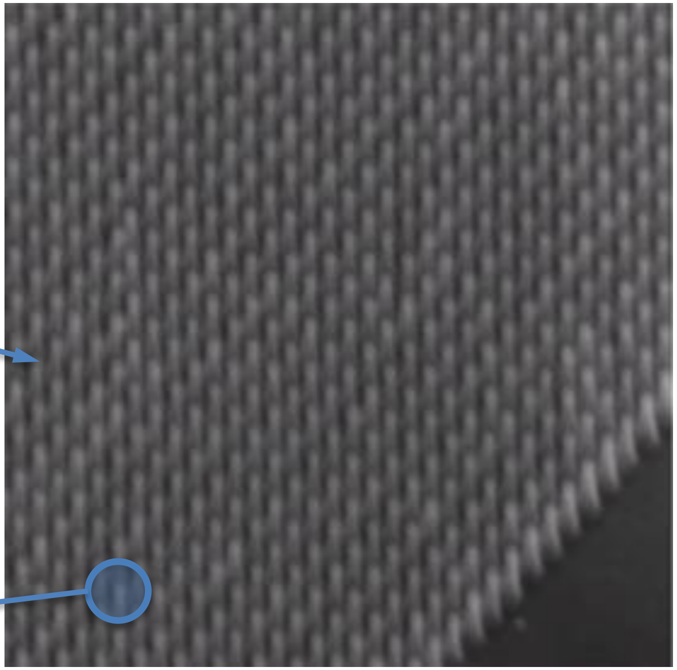
La « loi » de Moore



Taille typique: 1000 nm 200 nm 80 nm 1 nm

Why « nano » : data storage





Data unit = Magnetic grain

L = 200 nm

Capacity: 1 Gb / cm^2

Data unit = Single nanoparticle or molecule

L = 2 nm

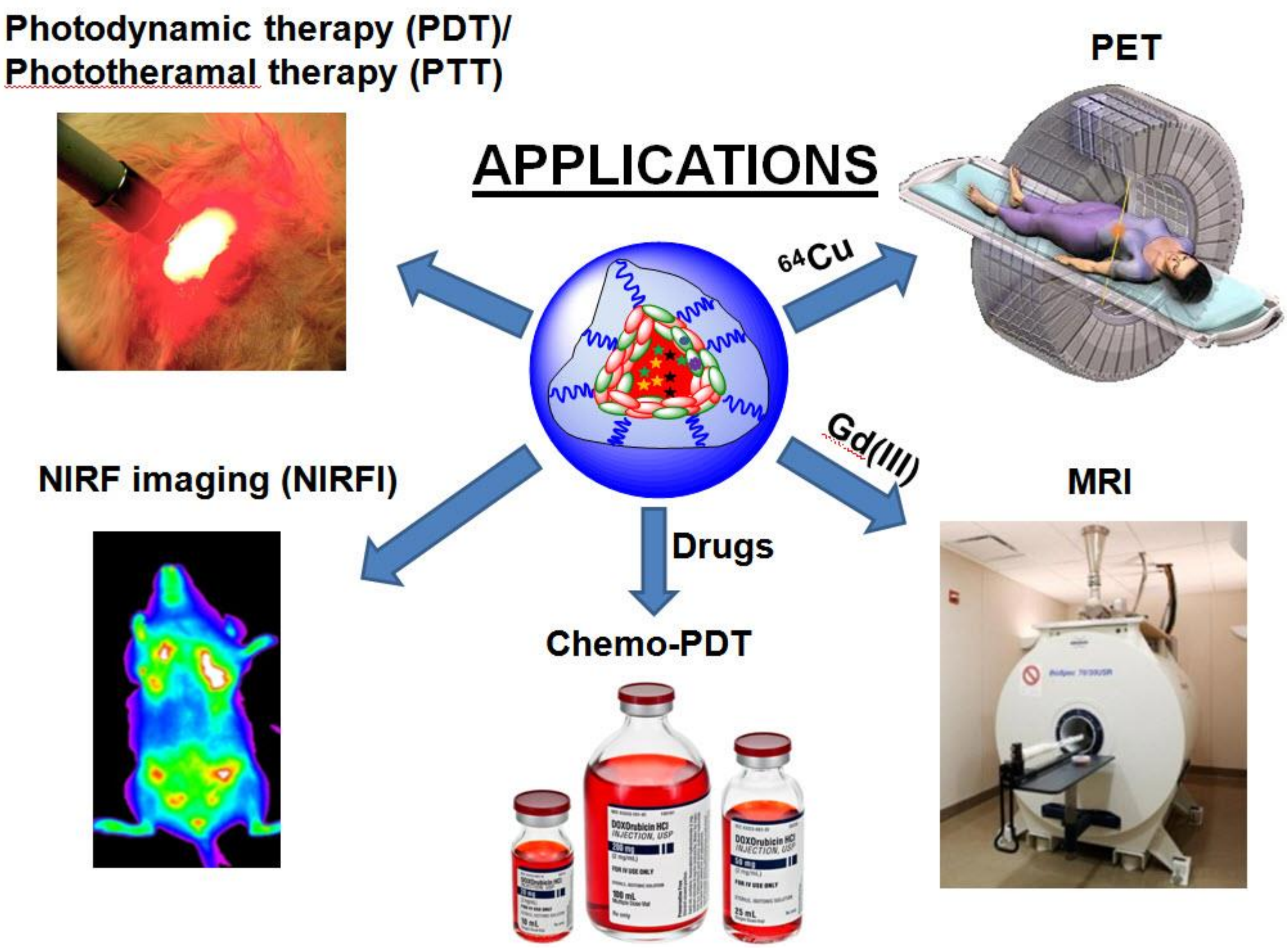
Capacity: 10^4 Gb / cm^2

Store information in single nanoparticles or molecules?

How to read and write ?

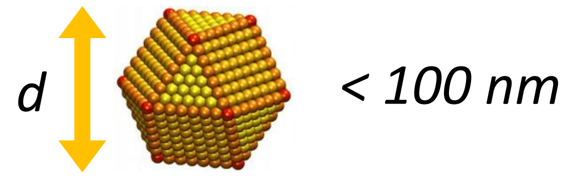
Why « nano » ? : advanced medicine

Nanoparticles

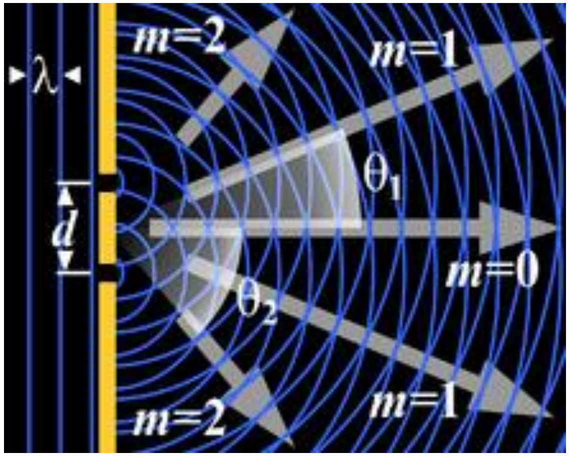


Which are our means to study individual nano-objects ?

- **Abbe diffraction limit for an optical microscope**



$$d = 0.612\ \lambda / (n \sin \alpha)$$



- **Other types of radiation**

Nature	*Longueur d'onde (nm)*	*Energie*
Photons (visible)	**400 - 700**	**≈ 2 eV**
Photons (domaine X)	**5×10^{-2} - 1,25**	**25 keV - 1keV**
Electrons	**10^{-3} - 3×10^{-3}**	**1 MeV - 100 keV**
Protons ou ions	**≈ 10^{-4}**	**≈ 10 keV**
Neutrons	**≈ 0,1**	**≈ 0.025 eV**

Electrons: $m_{0,e-}$=9.1091 10^{-31} kg et $E_{0,e-}$=0.511 MeV:
relativistes en microscopie électronique à transmission(E>100 keV)
non relativistes en diffraction d'électrons lents (E ≈ 10 à 1000eV).

$$\lambda_{e-}[m] = \frac{1.23\cdot10^{-9}}{\sqrt{E\left(1+\frac{E}{2E_0}\right)}} \cong \frac{1.23\cdot10^{-9}}{\sqrt{V_{acc}+10^{-6}V_{acc}^2}}$$

V_{acc} tension d'accélération des électrons en volts λ_{e-}=2.0 pm à 300 kV

Max. Résolution: 10^{-6} m

ex.: for λ = 400 nm results d = 203 nm ≈ λ / 2

It is not an optical microscope which can see the « nanometer».

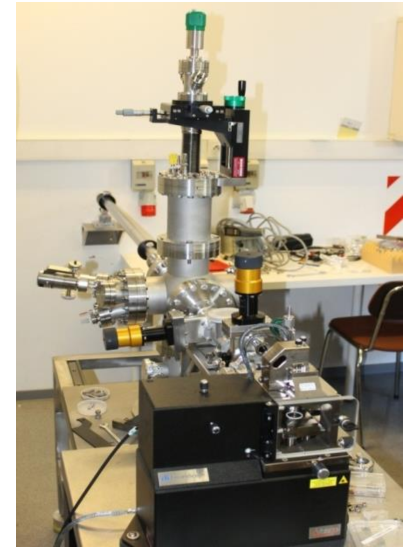
Research and Innovation at IPCMS

5 Research Departments – 145 members + (50 < PhD students, 40 < Master students)

e -microscopy

X- ray

STM

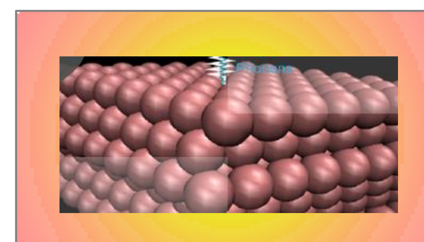


AFM

Chemistry

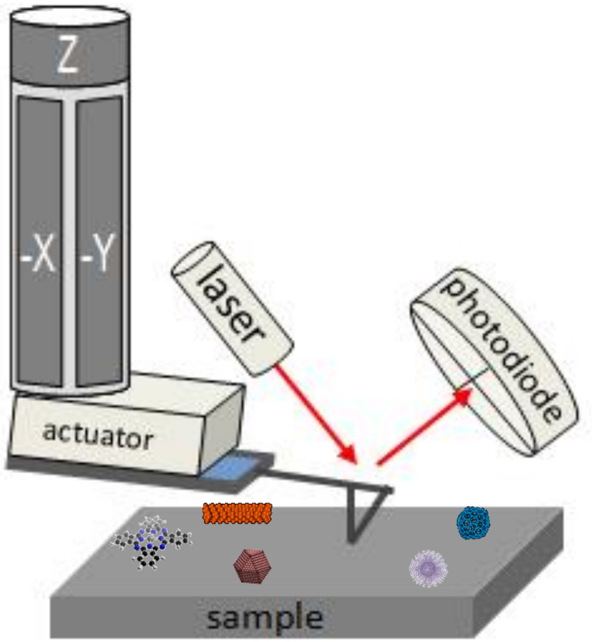
Optics

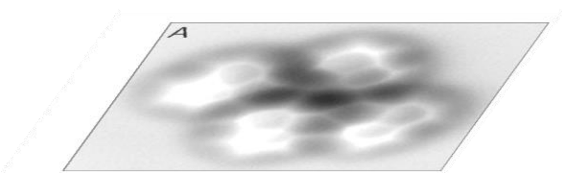
Theory & Calculations



What can be done with an Atomic Force Microscope (AFM) ?

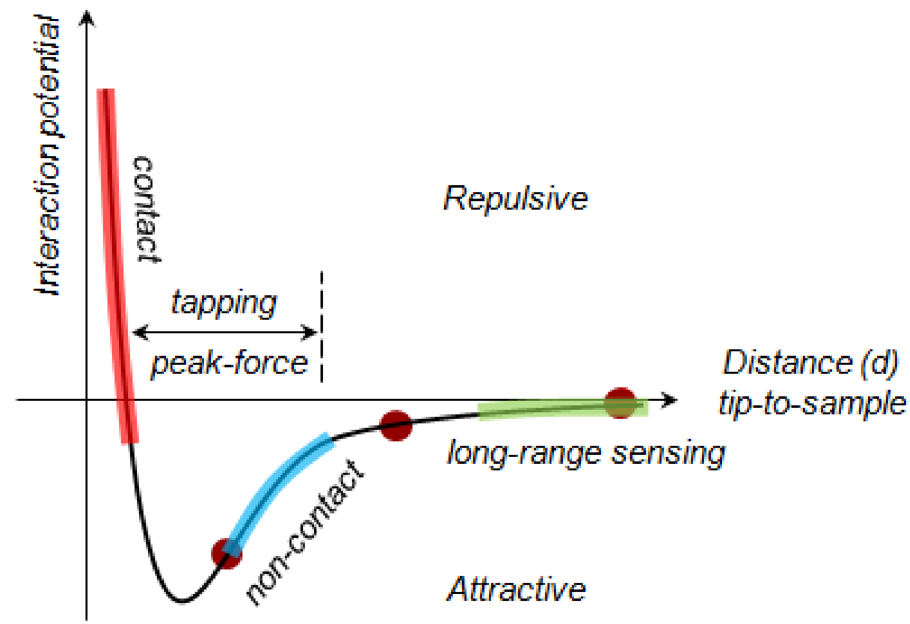
AFM Imaging





AFM Spectroscopy

F *vs.* (*d*, *E*, *B*, $\hbar\omega$)

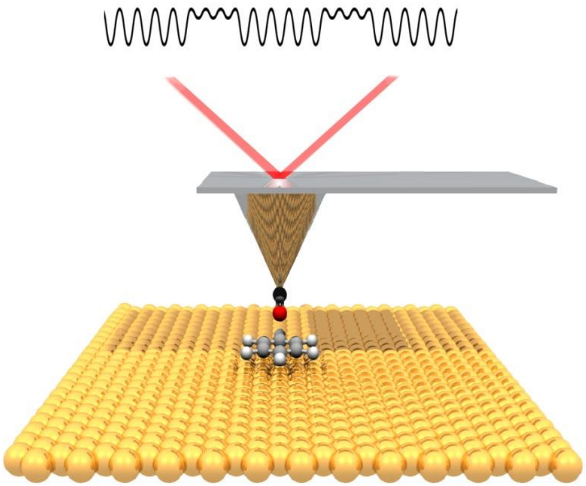


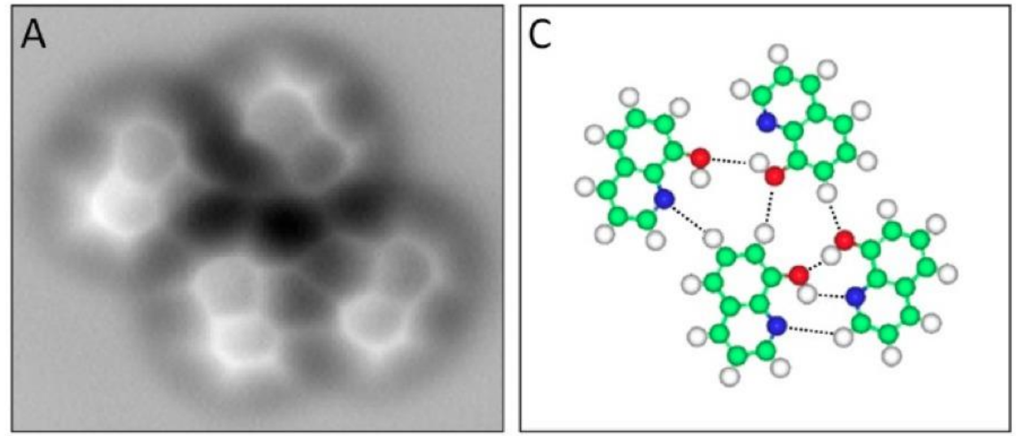
Equation of motion : driving, local forces, optomechanics, thermal …

$$m_{eff}\frac{dx^2(t)}{dt^2}+m_{eff}\Gamma_m\frac{dx(t)}{dt}+m_{eff}\Omega_m^2x(t)=F_{Drive}(t)+F_{k_BT}+F_{Quantum}+$$

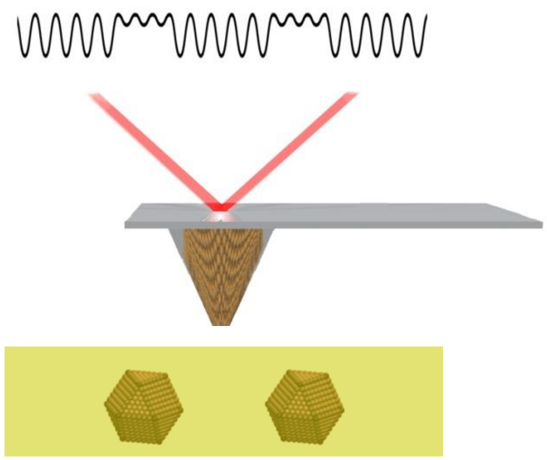
$$+F_{Interaction}(d,E,B,\hbar\omega)+F_{rad}(t,\hbar\omega)$$

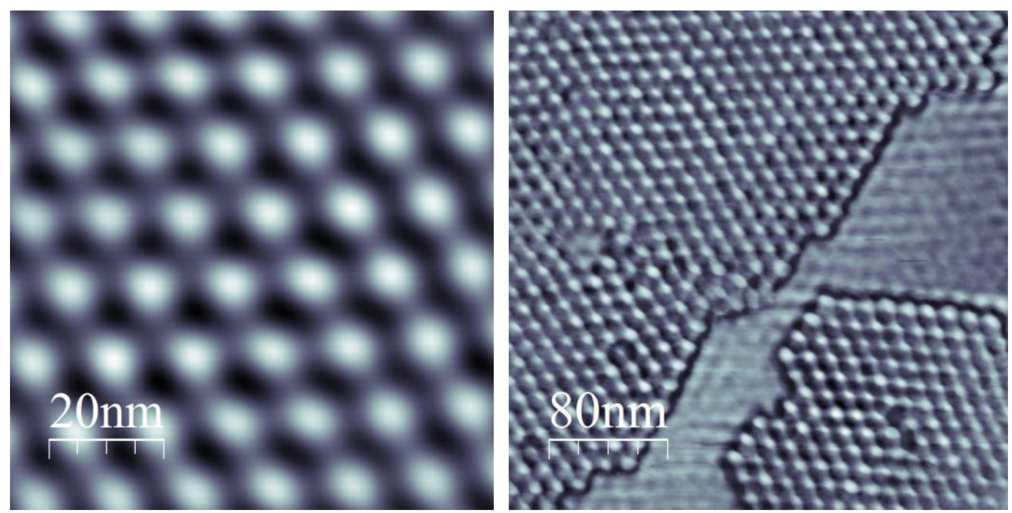
High-resolution imaging





IBM Zurich





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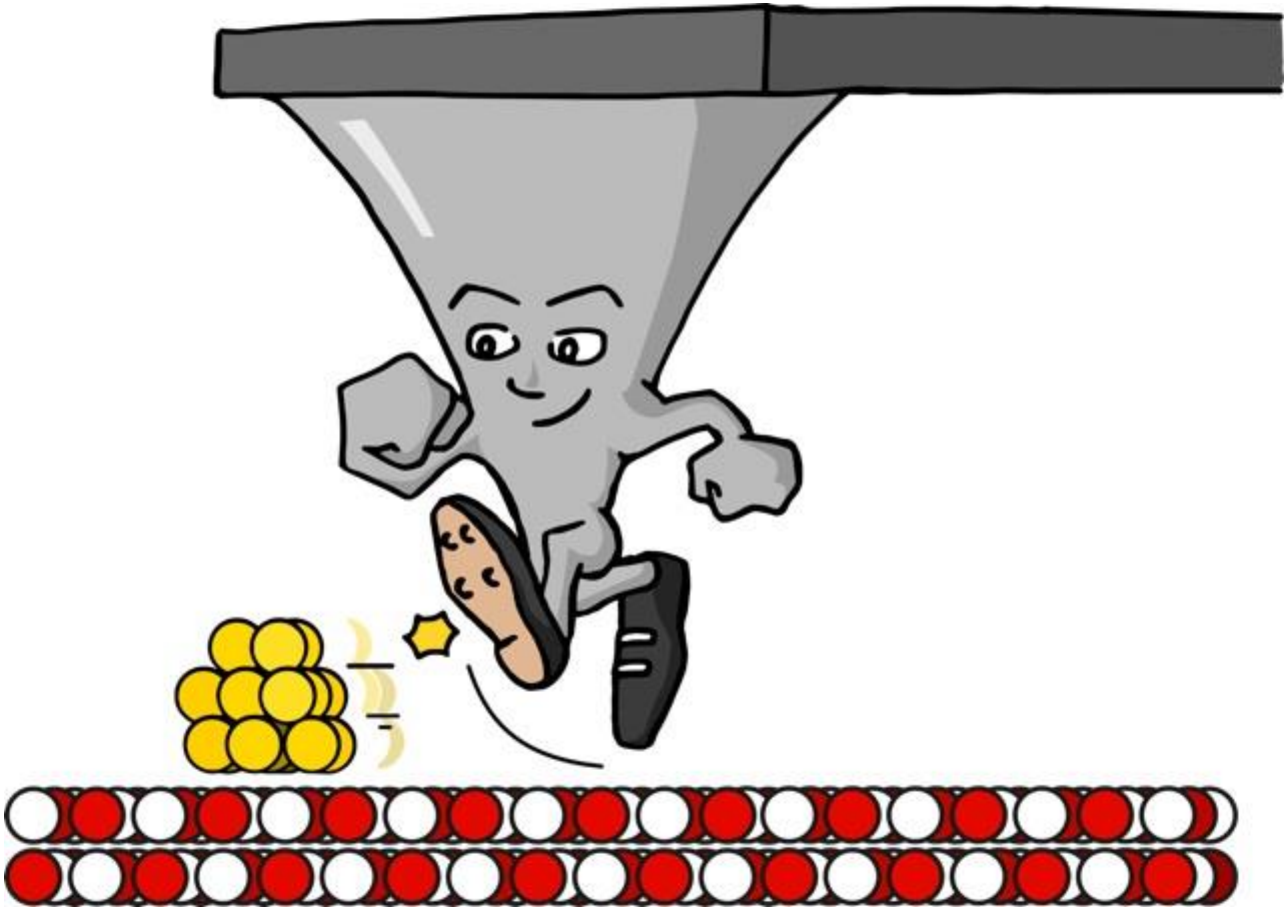
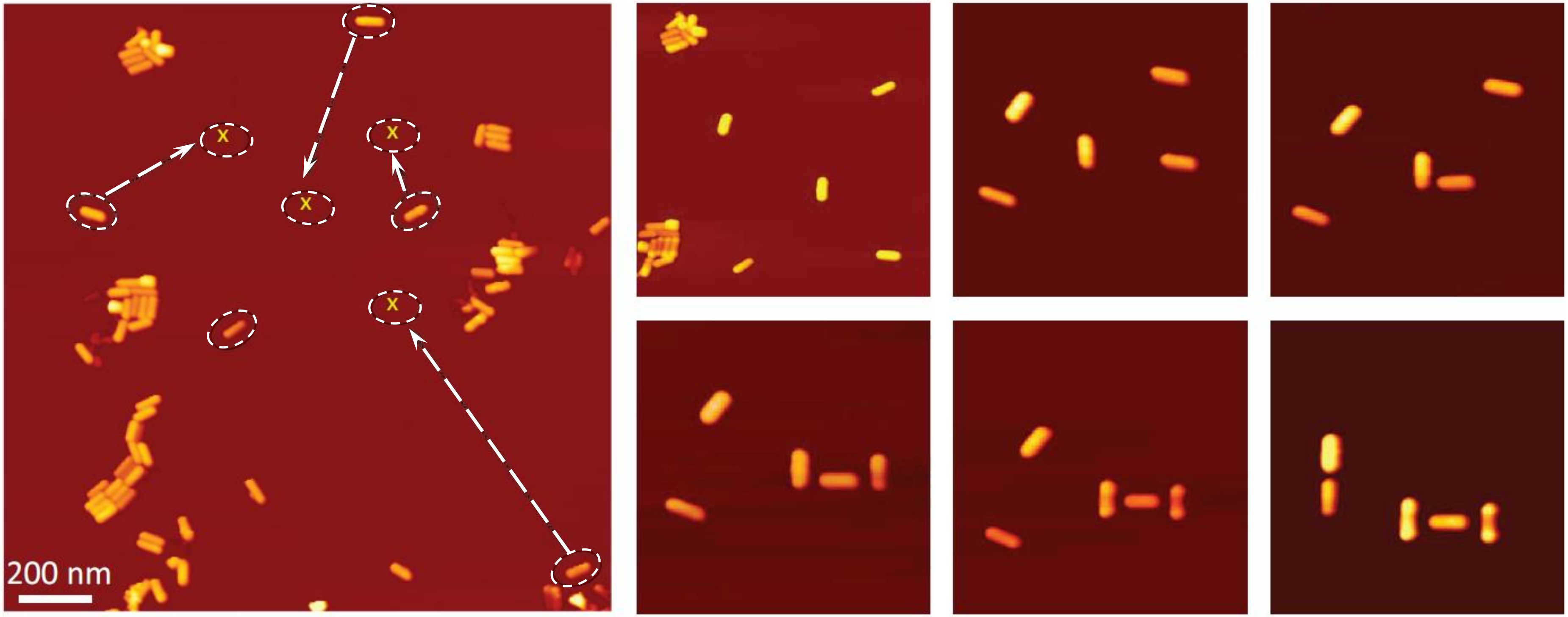
Nanomanipulation



Nanomanipulation of Nanoparticles



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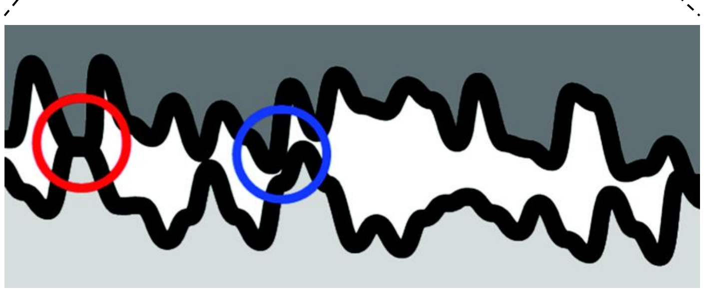
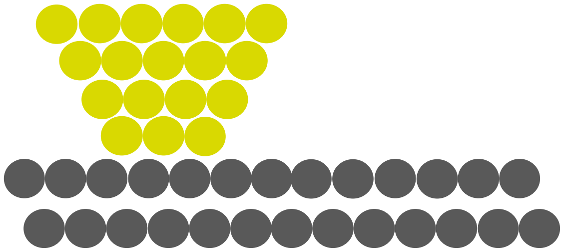
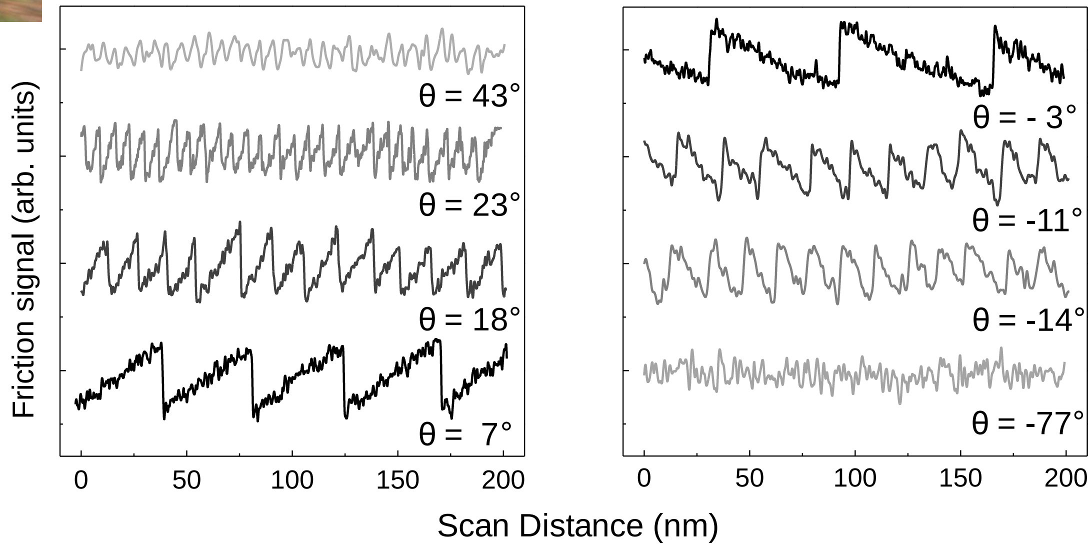
Contact force measurements: nanoadhesion, nanofriction, etc







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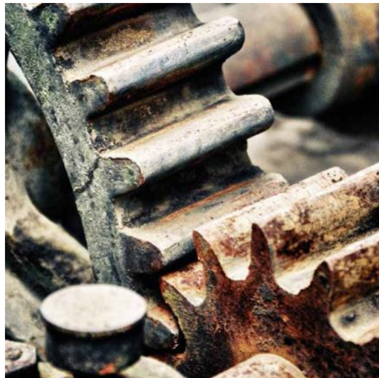
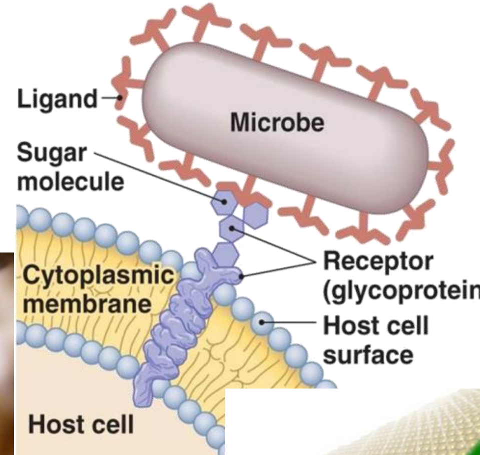
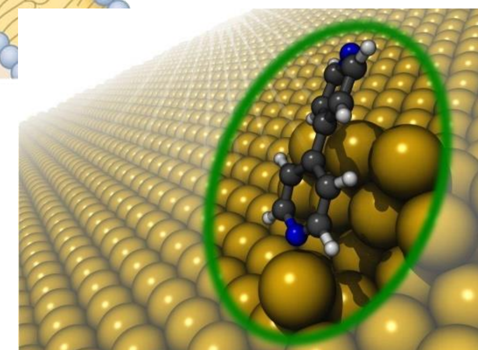
NanoAdhesion & NanoFriction by AFM





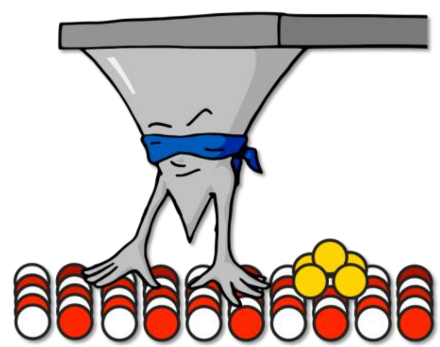


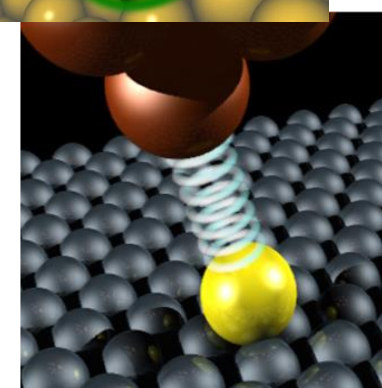
Where does it come from?

- Covalent, ionic, metallic bonds
- Electrostatics
- Van der Waals
- Mechanics, etc

Parameter → Surface roughness

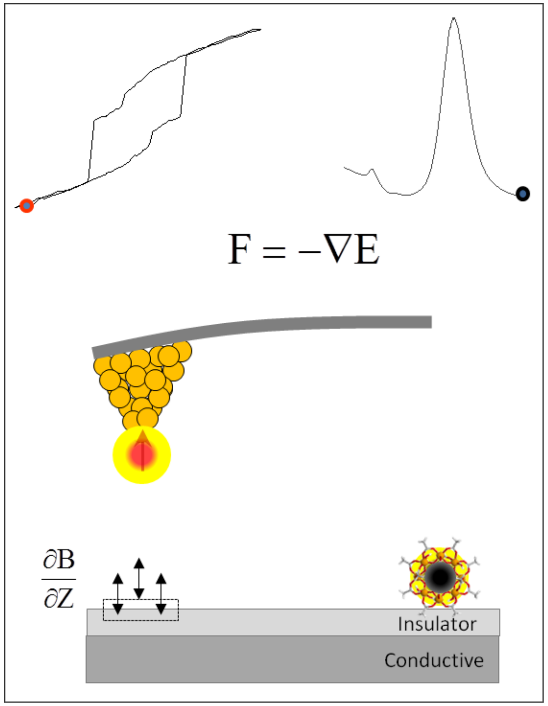
Nanoscale AFM



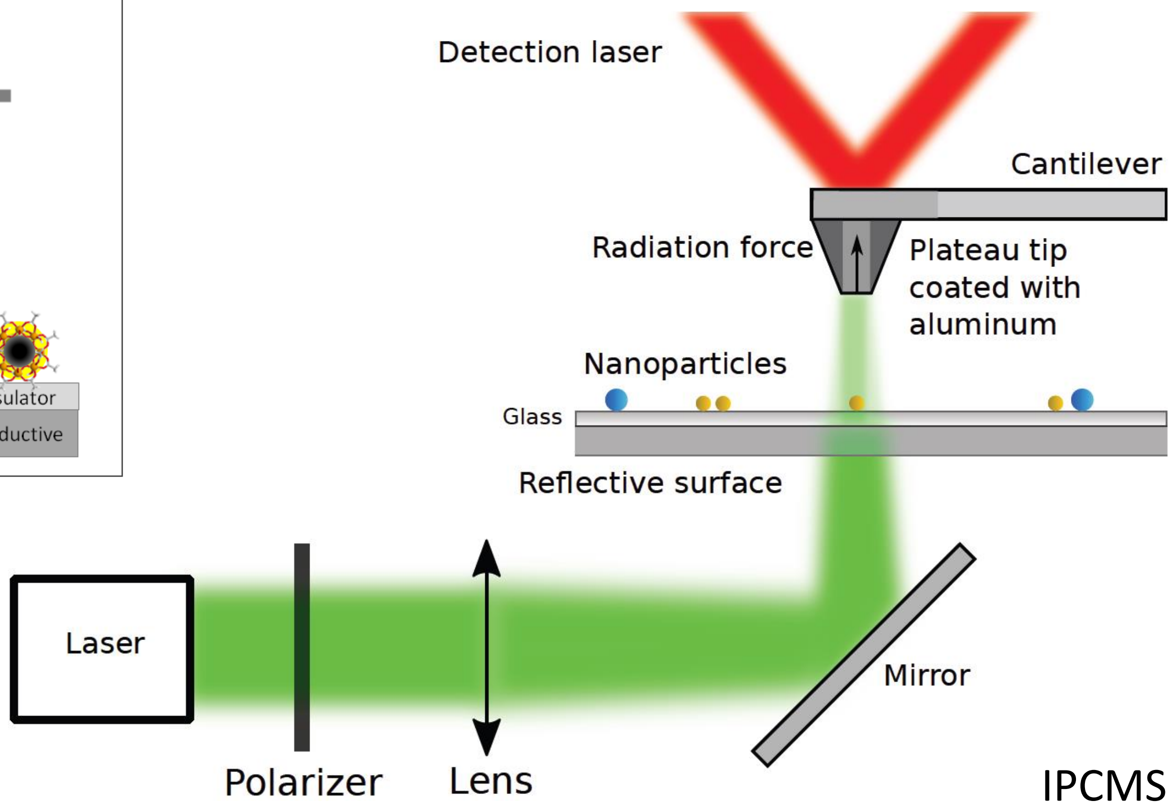


Magnetic and Optical spectroscopy

Magnetism



Absorption spectroscopy

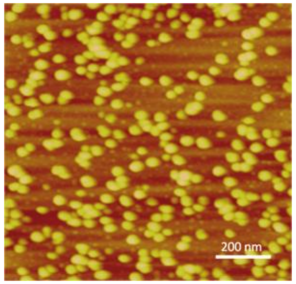


IPCMS Strasbourg

AFM in Strasbourg

IPCMS

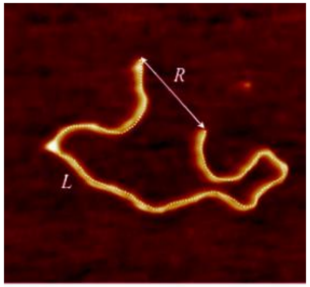
Nanophysics, Properties of Single Nanoparticles



Nanoparticles

ICS

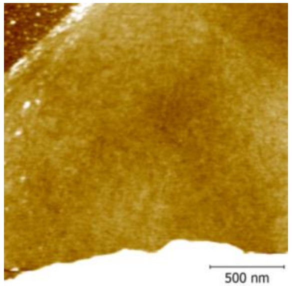
Soft matter physics



DNA imaging

ISIS

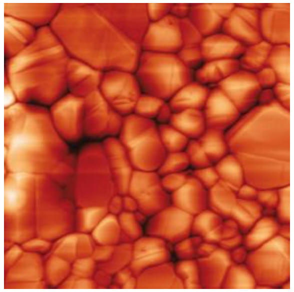
Supramolecular and functional materials



Graphene

ICUBE

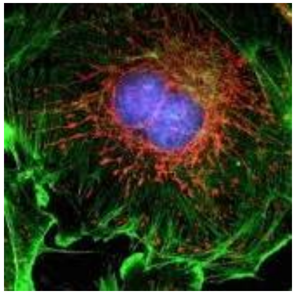
Materials for electronic & photovoltaic devices



PV thin film

IGBMC

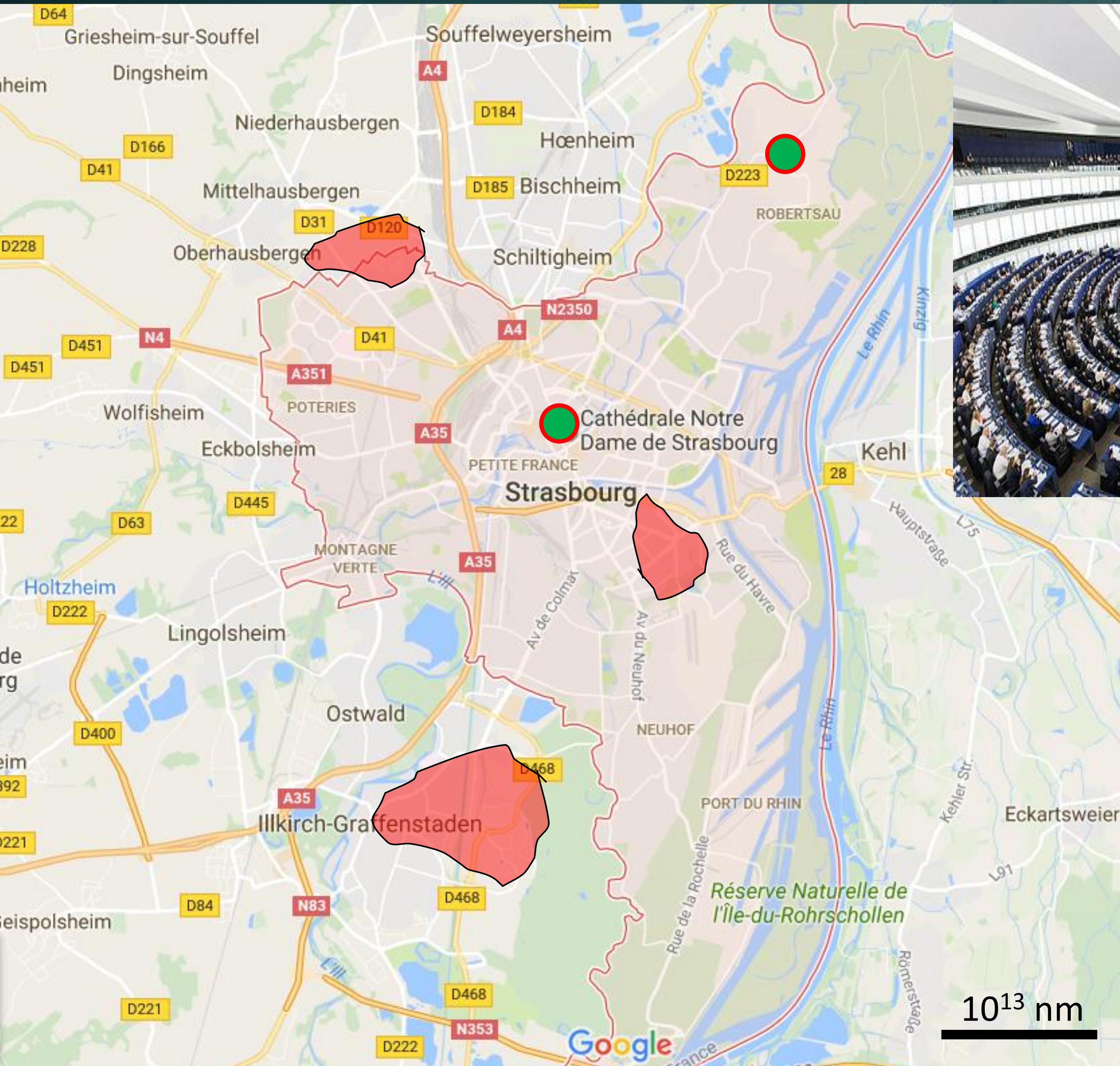
Biology & Physics of Cells



Cell imaging

Total:
14
AFM
microscopes

Campuses in Strasbourg



10^{13} nm