

micro and nanoelectronics  
microsystems  
ambient intelligence  
image chain  
biology and health

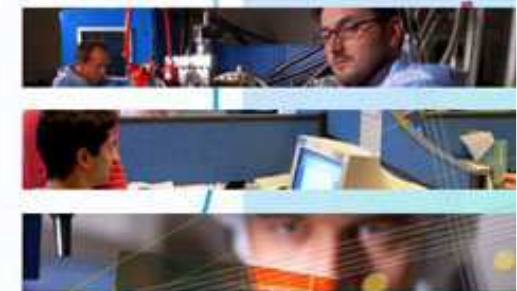


## Application of nanotechnology in medical diagnostic

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cea

leti



# Key challenges in nanomedicine

- Translating breakthroughs in understanding of disease into preventive medicine
- How to increase productivity dramatically ?
- How to align reimbursement with better outcome and efficiency ?
- How to design affordable healthcare for the bottom-of-the-pyramid ?
- How to reap the benefits of healthcare while reducing the inefficiencies ?
  - Largest factor of a country's economic growth



# How could nano revisit diagnostics?

- Manufacturing new entities, new materials
  - Self assemblies
  - Nanoparticles
- New carriers
  - Imaging agents (multimodality)
- Reducing the size of sensing devices
  - Less invasive
  - Using less sample
  - Faster reactions
  - Multiplexing



# Pros and cons of miniaturisation

## ■ Benefits

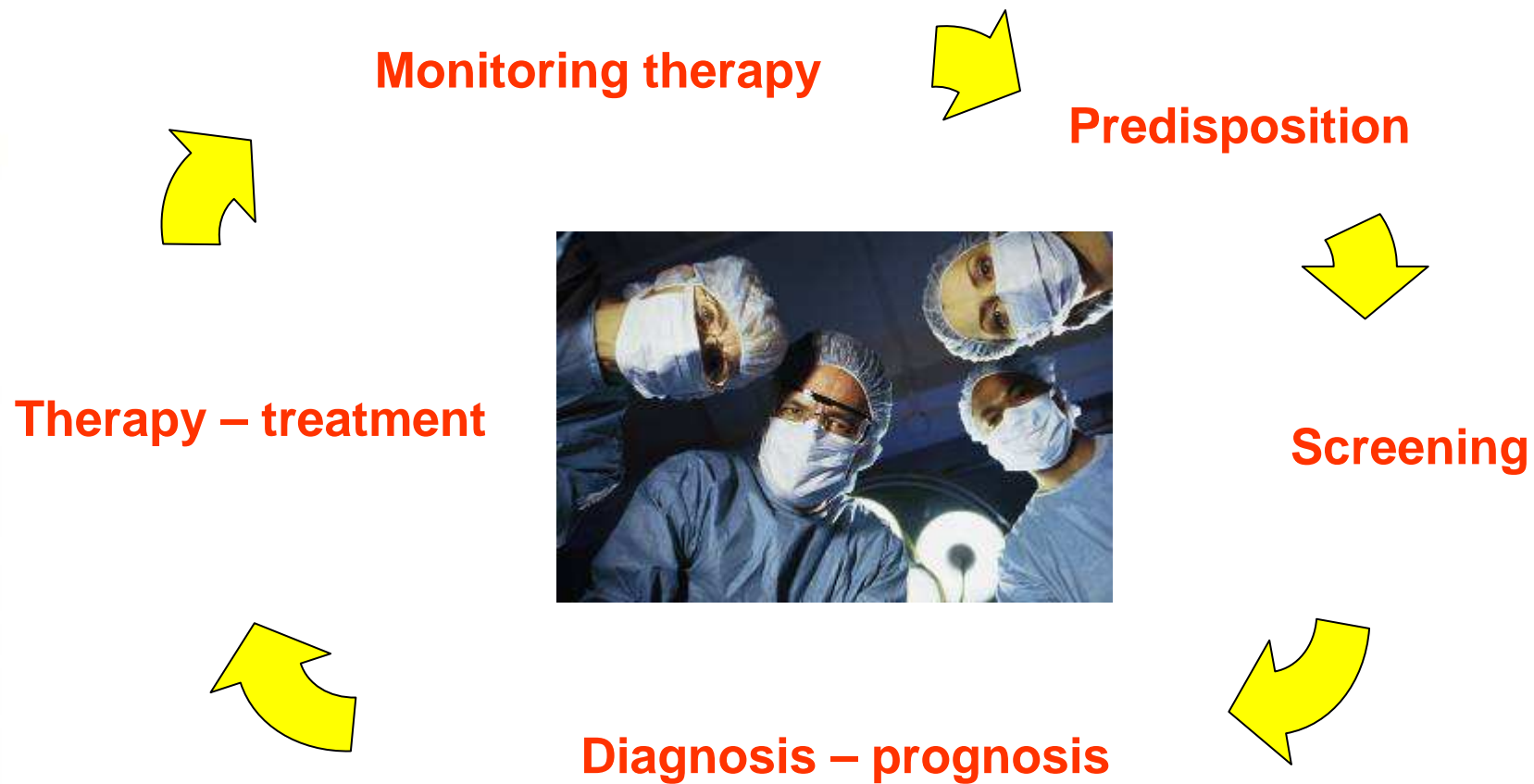
- Smaller biological sample
- Integration of various analysis
  - ◆ Point of Care analysis
- New physical laws
  - ◆ Faster reaction time
  - ◆ Surface  $\gg$  volume

## ■ Limits

- New physical laws
  - ◆ Microfluidics
  - ◆ Capillary forces  $>$  gravity
- Precise mass production
- From macro to micro and nano



# Diagnosics along the care cycle



# At the crossroad of disciplines

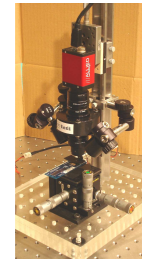
Optical  
detection



Electrochemistry



Instrumentation

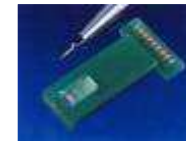


Biology

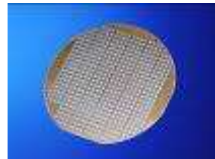


Diagnostics

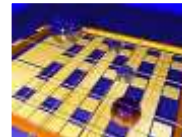
Packaging



Microtechnologies,  
microelectronics



Microfluidics

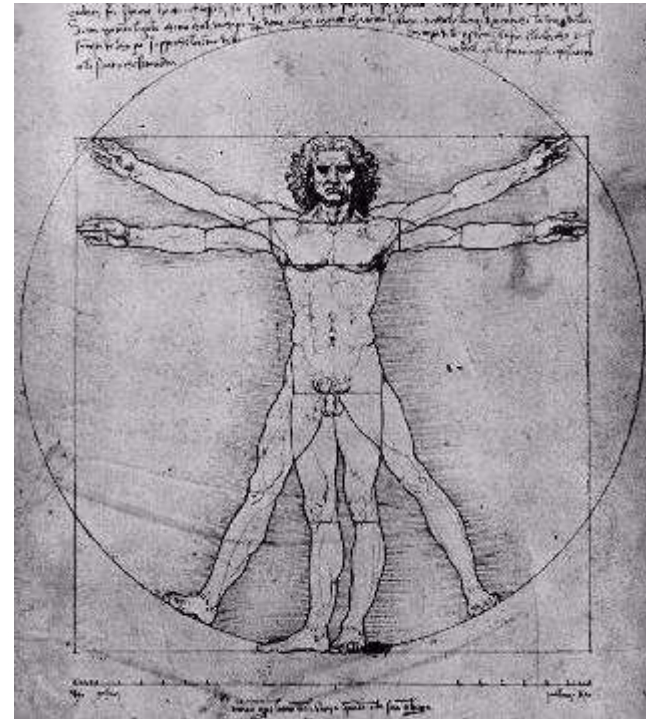


Chemistry  
Biochemistry



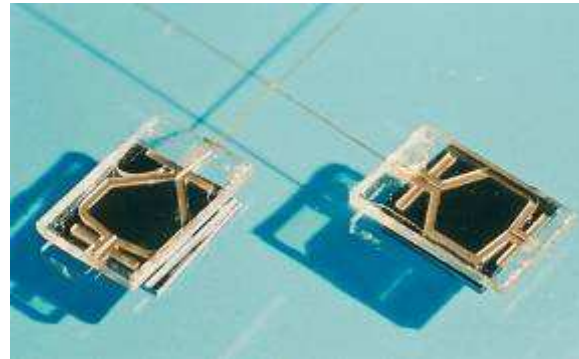
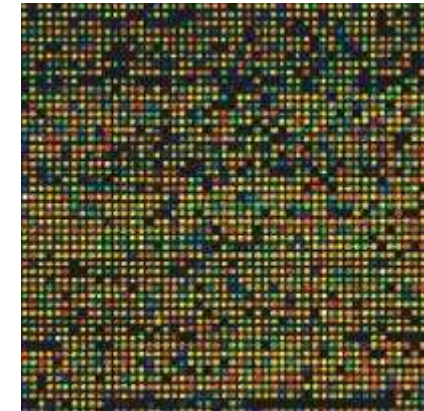
# An overview of clinical diagnostics

- **In vitro** diagnostics
- **In vivo** diagnostics
  - Molecular imaging
  - Implantable devices
  - Nanobiopsy
- **On vivo** diagnostics
  - Wearable sensors



# Examples in IVD

- DNA Chip
- Lab-on-Chip
- Cell-on-Chip



# Point Of Care based on DNA analysis



## In-Check™ Platform

**Amplification « in-chip » PCR (Polymerase Chain Reaction)**

**PCR**

Thermal module (TCS)

**DNA chip**

probes spotting

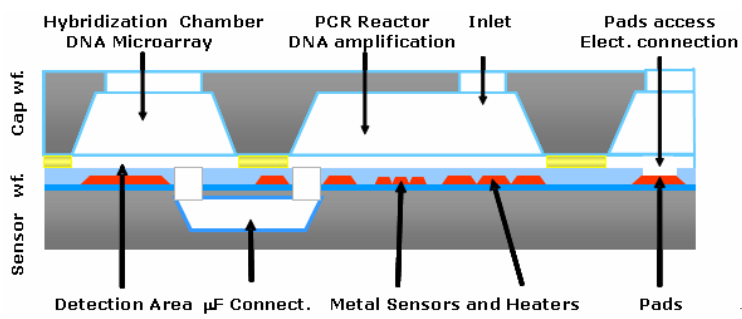
CY3 target 10 nM

CY3 target 1 pM

**Buried channels**

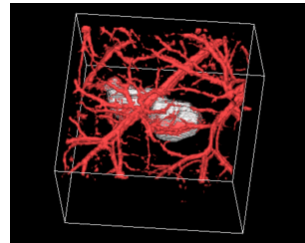
**MICROFLUIDICS**

Clamps

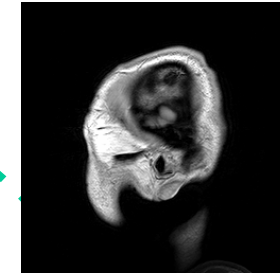


**reader**

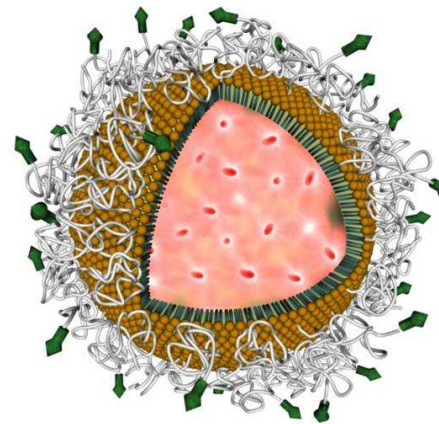
# Example in (multimodal) imaging



Optoacoustic



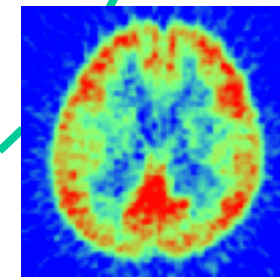
MRI



Nano Particles



Ultra Sound



PET

# In vitro diagnostic - recent trends

## ■ Central labs vs decentralised POC

- in the long term, saturation of central lab
- The trend towards the physician's office and ultimately the home of the patient becomes inevitable.
- More robust systems, easy to operate without technical training, offering fast response and the delivery of easy analysable data by the practitioner.



## ■ Multiplexed analysis to offer doctors or patients a more comprehensive and personalised diagnosis

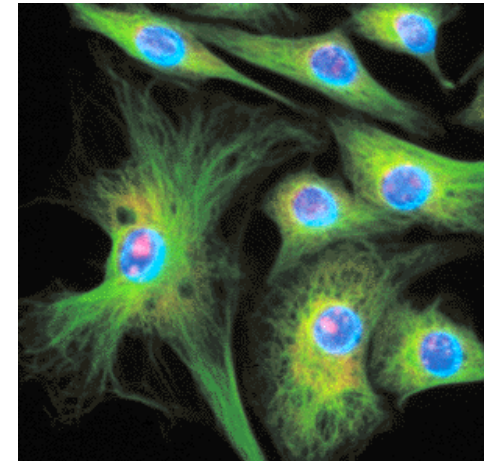
## ■ Co-development of companion test and pharmaceuticals

- Driving force for the next stage

# Technical challenges in POC

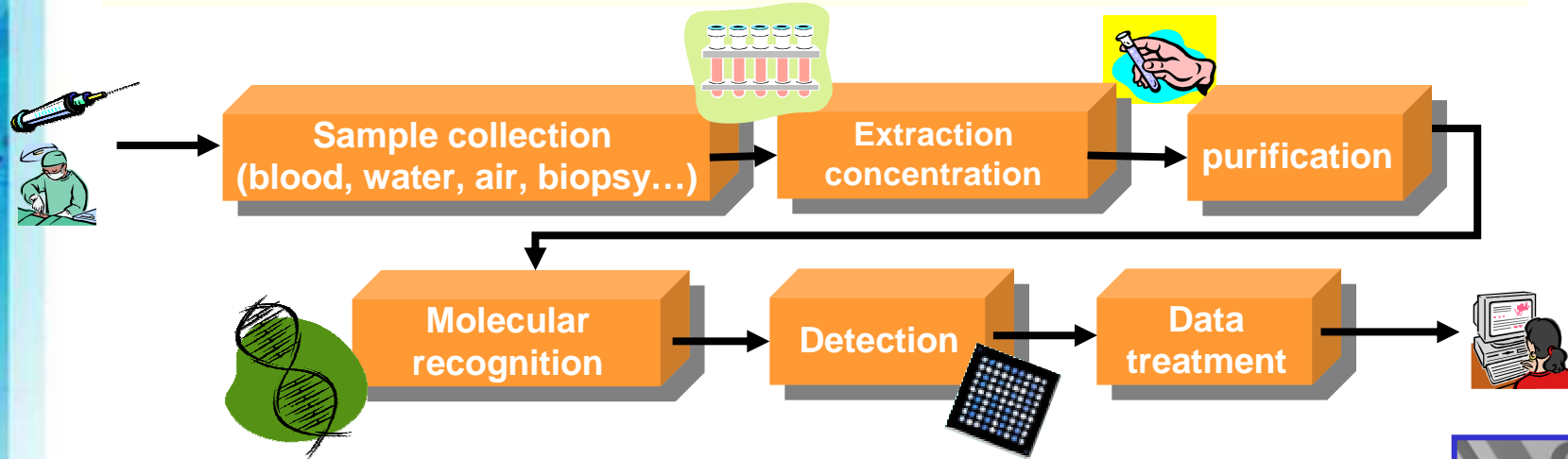
## ■ Specific properties of POC, multiplex analysis

- Lab quality results in minutes (sensitivity and speed)
- Robust, 'fool-proof' results under all circumstances (precision)
- High predictiveness and reliability
- Less invasive sample taking (finger-prick blood, saliva, urine)
- Integration into healthcare system



# Ex #1: The challenge of integration

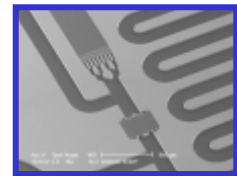
Microtechnologies & microfluidics are necessary to miniaturize and integrate all the steps of a biological or chemical analysis



Miniaturisation



*Batch fabrication, low sample or reagent volume, reproducibility, sensitivity ...*



Integration



*Sequential and/or parallel reactions (biological protocol)*



Automatisation



*Automated device → point of care*



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# Technical challenges related to biomarkers

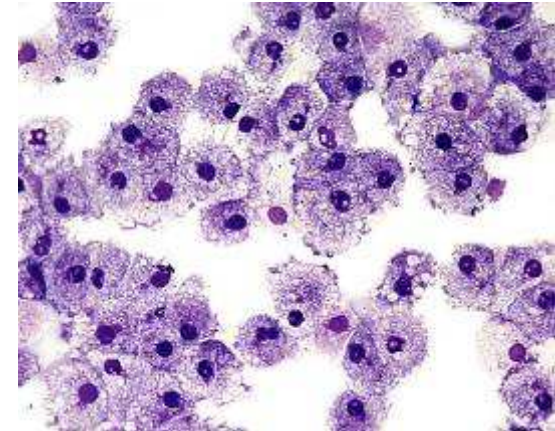
## ■ Sharper analysis of biomarkers in biological samples

### ● Challenges

- ◆ Identification of biomarkers
- ◆ Validation of biomarkers
- ◆ Overcoming assay interferences

### ● Breakthrough elements

- ◆ Design new non isotopic reporters with adequate sensitivity (transducers)
- ◆ Design sensitive reporters to monitor interactions between biomolecules
- ◆ Design new technologies to deliver proper analytical reagents into cells and sub cellular compartments
- ◆ Design new technologies to tag specifically proteins of interest in living cells.
- ◆ Design new bioprobes



# Non technical aspects of IVD

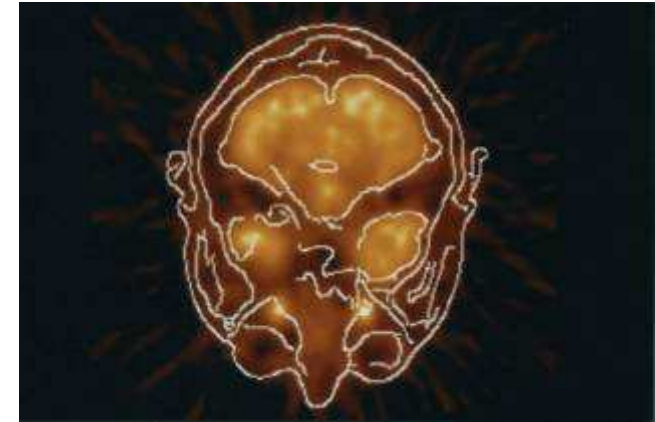
- Ethical
  - Who will deliver the new diag?
  - How does POC will change the doctor patient relationship?
- Legal
  - Transfer of decision? of responsibility?
- Social
  - Who will afford the extra costs?
- Financial
  - The policy of healthcare systems towards POC, especially its reimbursement policy will dramatically determine the emergence of this industry
- Education
  - Training of operators



# In vivo diagnostic - Recent trends

## ■ Challenges

- Approval for new contrast agents
  - ◆ imaging agents considered similar to drugs
- Improvement of existing modalities
- Training of end-users (operators?)
- Healthcare reimbursement policy



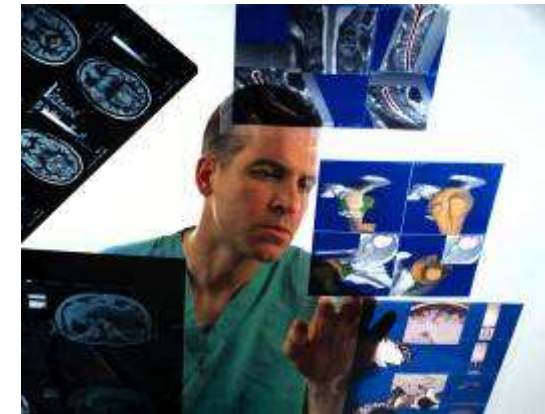
## ■ Input from nanotech

- Improving the existing and/or discovering new quantitative imaging systems
- Developing new contrast agents for enhancing contrast
- New physical and chemical properties at the nanoscale

# Trends in imaging modalities

## ■ Improvement of existing imaging modalities like PET, MRI, SPECT, US

- lightweight, small footprint CT system
- disruptive technology using carbon nanotube based X-Ray sources in CT
- to bring CT to the doctor's offices or even to ambulances



## ■ Combination of imaging modalities

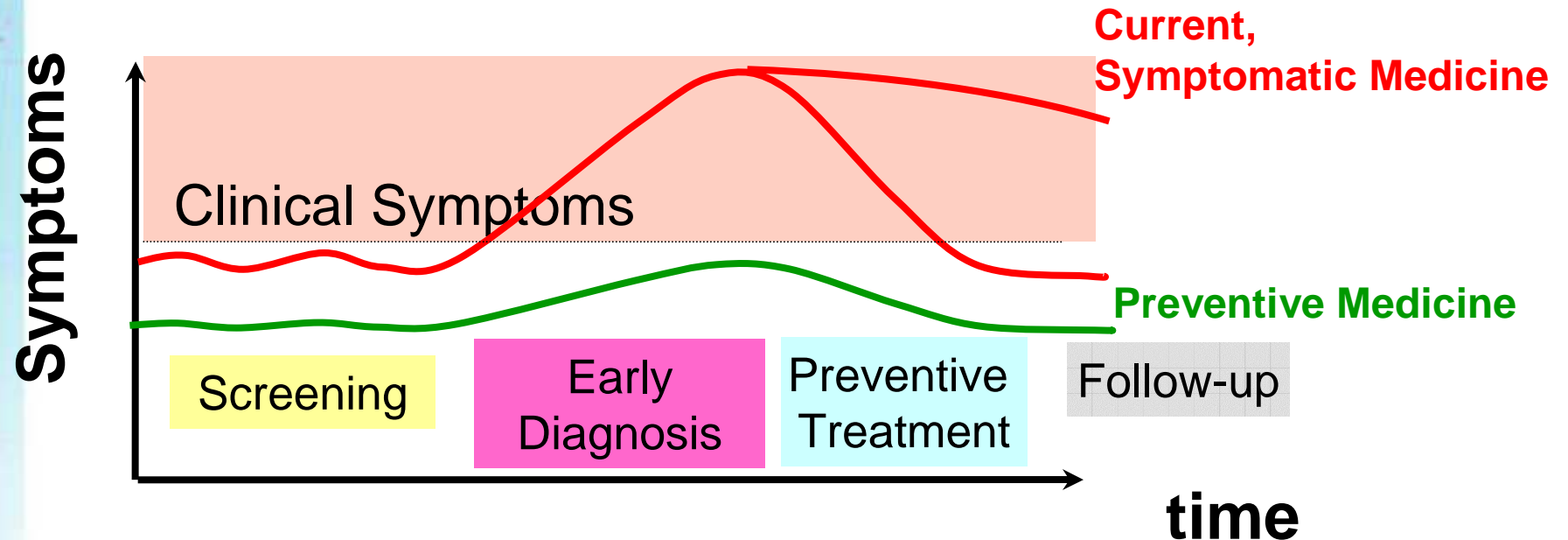
## ■ Image guided therapy for drug release or biopsy

# Trends in contrast agents

- Reducing dose
- Multi-modality contrast agents
- A strong emphasis on magnetic particles for MPI or MRI using (U)SPIO
- New carriers
  - magnetic nanoparticles, empty viruses or magnetic bacteria
- New types of NP: crystalline NP
  - For therapy or diagnostic
  - Externally triggered by MRI, Laser, Radiotherapy, CT Scan, Ultrasound, HF, etc.
- Upscaling of contrast agents could reduce costs



# Diagnostic and preventive treatment



- Through screening and early diagnosis find disease
- Early and intervene early

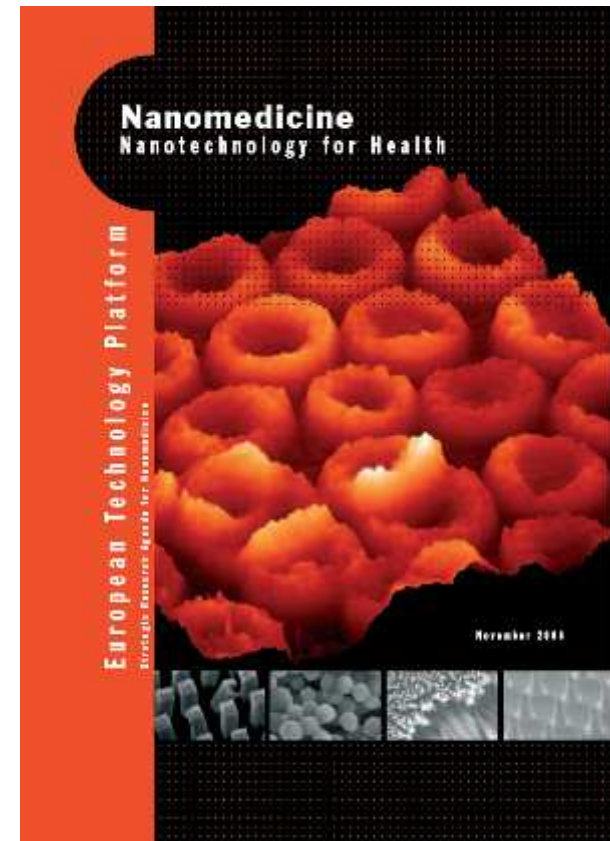
# Some concluding remarks

- The sustainability of healthcare systems recommends prevention rather than acute treatment
- The move towards preventive medicine requires much more powerful and earlier diagnostics techniques
- Nanotechnology is one way to contribute to revisit the medical diagnostics
- (Nano)technology is just one facet of diagnostic; don't forget the non technical aspects of nano-diagnostics

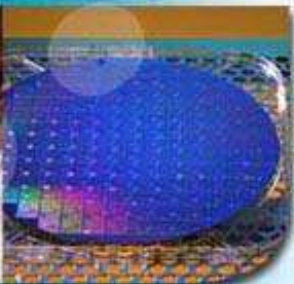
# ETP Nanomedicine



- WG on nanotech based diagnostics and imaging
- Main industrial players
  - Philips Healthcare,
  - Siemens Healthcare
  - GE Healthcare
  - Mérieux Alliance
  - Roche Diagnostics
  - And others
- Roadmaps towards industrial nanotech based products in medical diagnostics
- [www.etp-nanomedicine.eu](http://www.etp-nanomedicine.eu)



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