

*(Bio)Nanotecnologia/nanomedicina:
um mundo de oportunidades para as
ciências exatas e as engenharias*

José Figueiredo

(<http://w3.ualg.pt/~jlongras/>)
(jlongras@ualg.pt)

Departamento de Física
Centro de Electrónica, Optoelectrónica e Telecomunicações
Faculdade de Ciências e Tecnologia

2 de outubro de 2014

“Deus criou o mundo ...”



... e a nanotecnologia promete aperfeiçoá-lo

Plano da apresentação

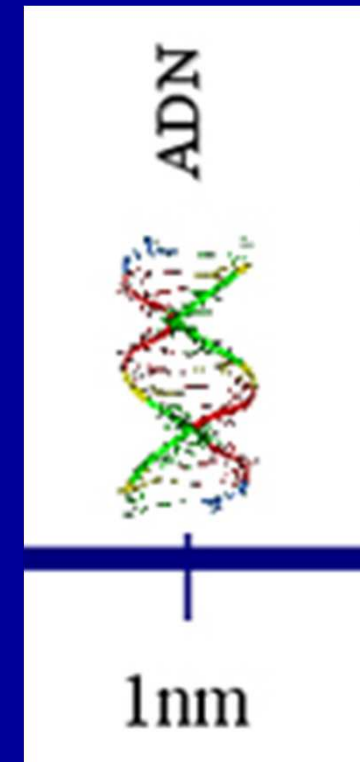
- O universo nanoscópico
- “Há muito espaço lá em baixo”
- Nanotecnologia
- Potencialidades e desafios
- Nanoferramentas
- Nanomedicina
- Nanoimplantes, nanorobôs e as comunicações sem fios

Nano-

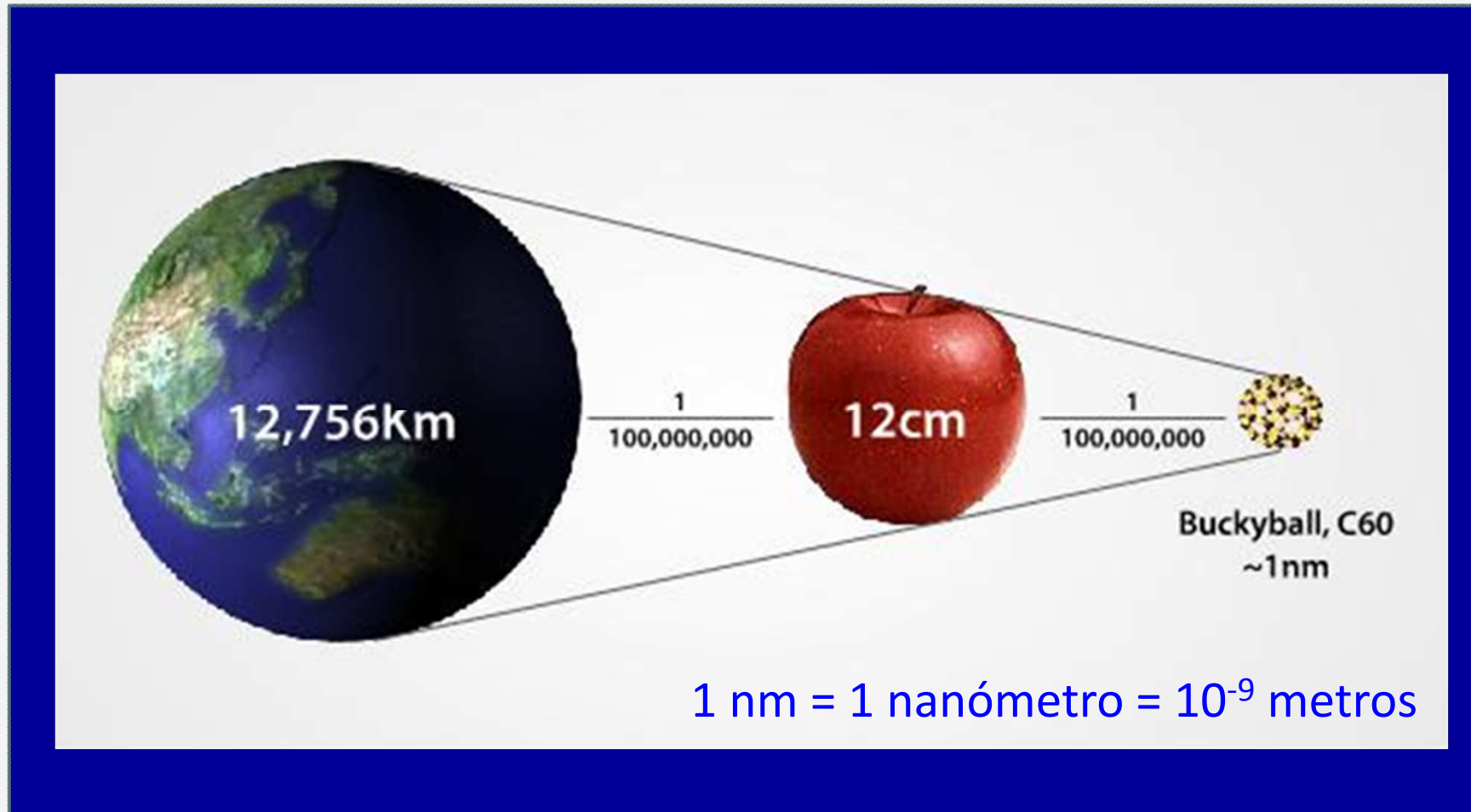
- do gr. nánnos, «anão»
- (fís.) designa um milésimo da milionésima parte

$$\text{NANO} = \frac{1}{1,000,000,000}$$

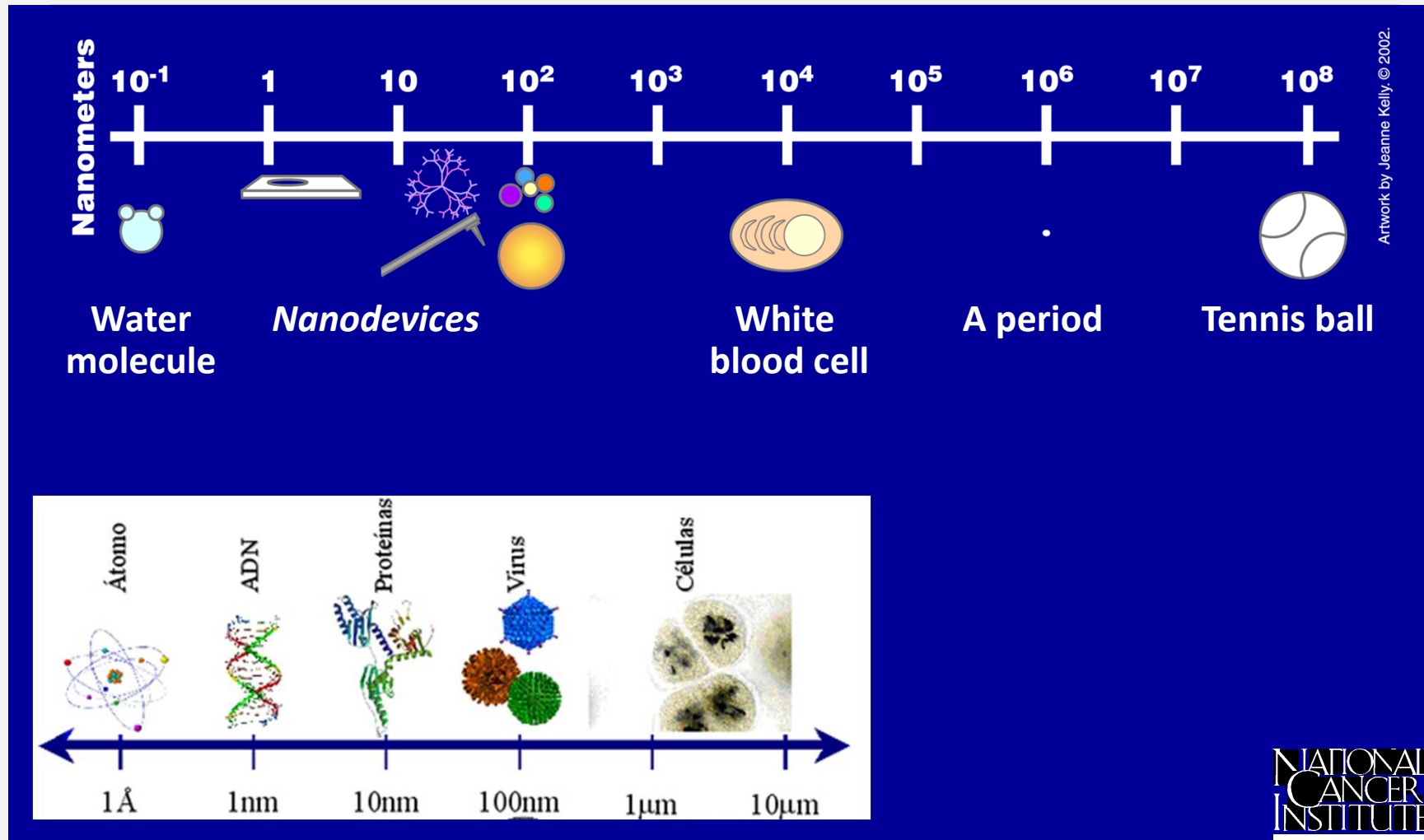
- 1 nanómetro = 10^{-9} metros = 1 nm



Nanómetro



Mundo nanoscópico (< ~100 nm)



Artwork by Jeanne Kelly, © 2002.

The Scale of Things – Nanometers and More

Things Natural

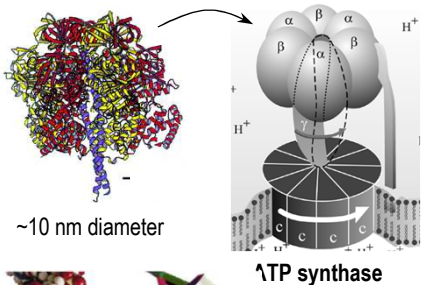


Dust mite
200 μm



Human hair
~ 60-120 μm wide

Red blood cells
(~7-8 μm)

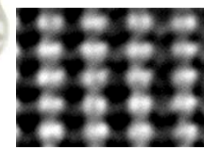


~10 nm diameter

ATP synthase



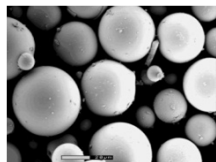
DNA
~2-1/2 nm diameter



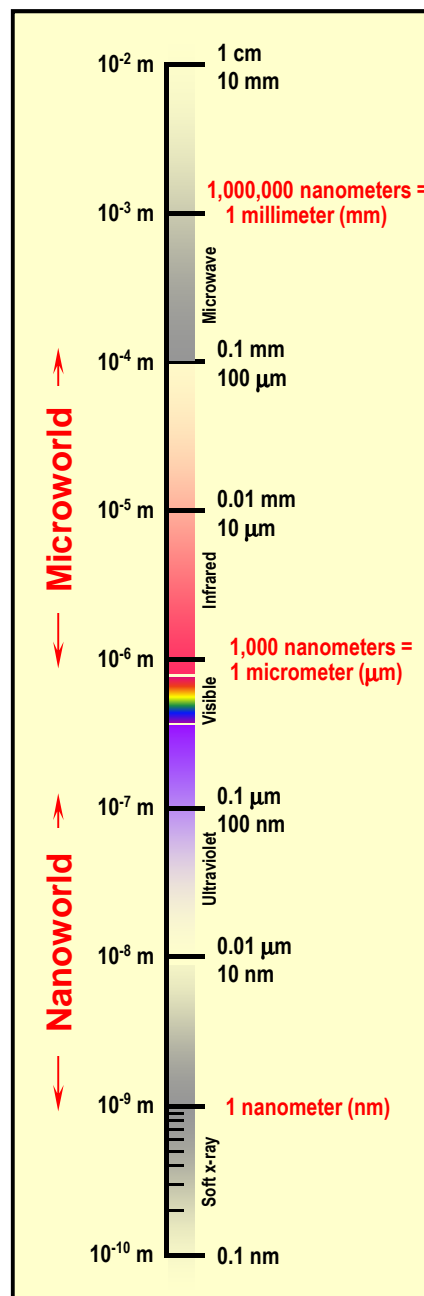
Atoms of silicon
spacing 0.078 nm



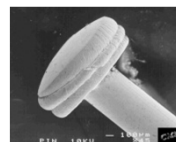
Ant
~ 5 mm



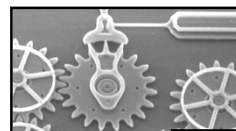
Fly ash
~ 10-20 μm



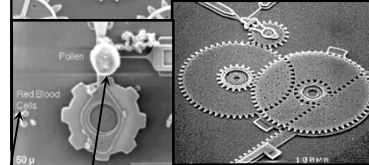
Things Manmade



Head of a pin
1-2 mm

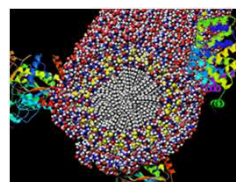


MicroElectroMechanical (MEMS) devices
10 -100 μm wide

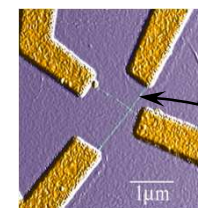


Pollen grain
Red blood cells

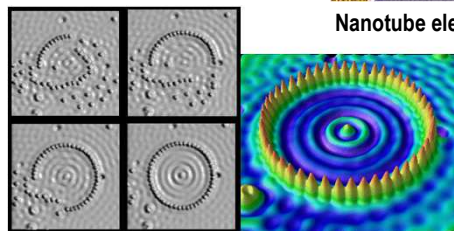
Zone plate x-ray "lens"
Outer ring spacing ~35 nm



Self-assembled,
Nature-inspired structure
Many 10s of nm



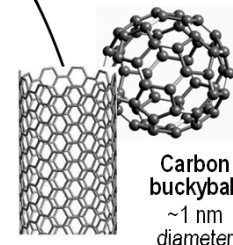
Nanotube electrode



Quantum corral of 48 iron atoms on copper surface
positioned one at a time with an STM tip
Corral diameter 14 nm

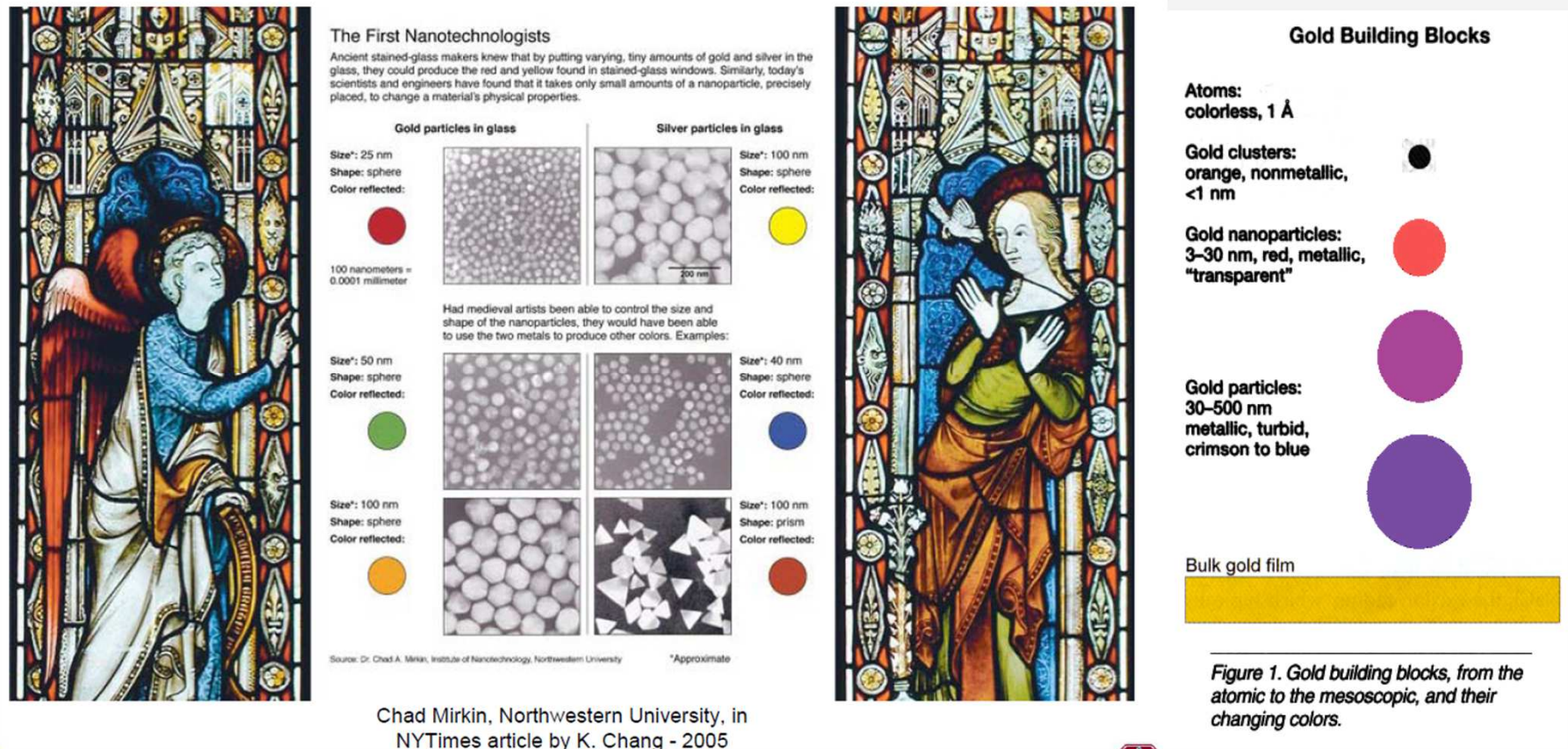
The Challenge

Fabricate and combine nanoscale building blocks to make useful devices, e.g., a photosynthetic reaction center with integral semiconductor storage.

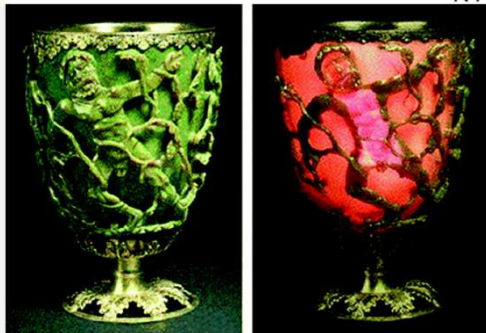


Carbon nanotube
~1.3 nm diameter

A nanotecnologia não é nova. De fato é milenar



Chad Mirkin, Northwestern University, in NYTimes article by K. Chang - 2005



O copo de Licurgo foi criado pelos Romanos em 400 a.C.. É vermelho quando iluminado de trás e verde quando iluminado na parte dianteira.

<http://www.youtube.com/watch?v=u-ld3pD1vEU>

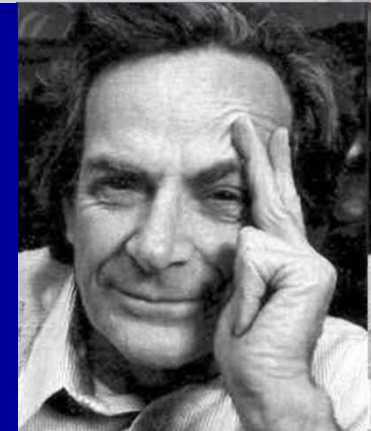
Nanotecnologia: potencialidades e desafios

“Há muito espaço lá em baixo”

“There’s Plenty of Room at the Bottom”*

* Título da palestra realizada por **Richard Feynman**, 29 de Dezembro de 1959.

- What would happen if we could arrange the atoms one by one the way we want them (within reason, of course; you can't put them so that they are chemically unstable, for example).

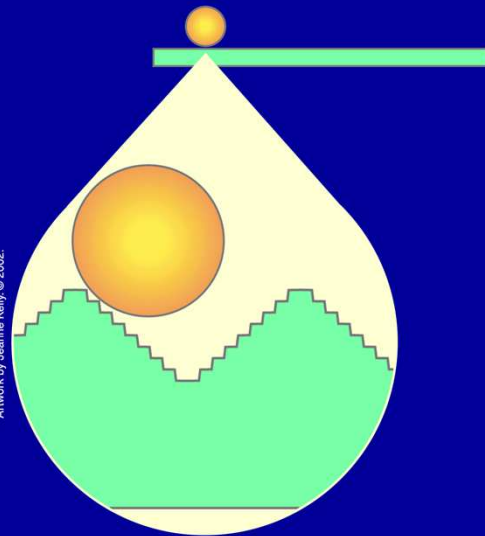


- I can't see exactly what would happen, but I can hardly doubt that when we have some *control* of the arrangement of things on a small scale we will get an enormously greater range of possible properties that substances can have, and of different things that we can do.

<http://www.zyvex.com/nanotech/feynman.html>

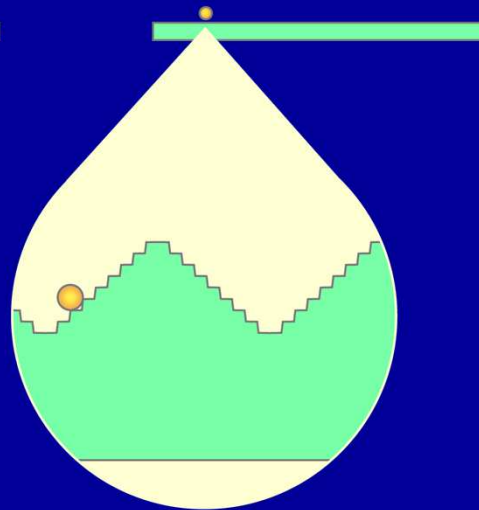
À escala nano a *física* é muito diferente

Normal Scale

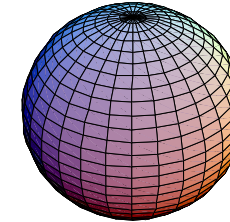


Artwork by Jeanne Kelly © 2002.

Nanoscale

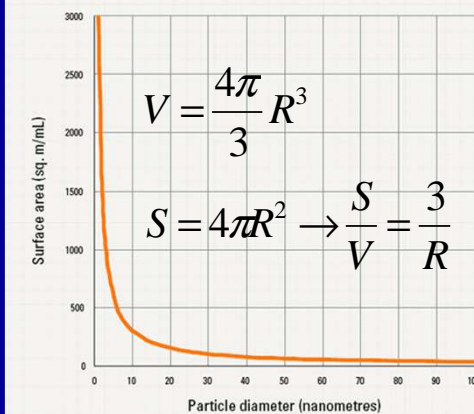


Fenómenos como o atrito, a adesão, os efeitos quânticos (ex. confinamento quântico e efeito de túnel), etc., passam a ter um papel crucial no mundo nanoscópico.



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h larger surface area
material in bulk form.



As nanopartículas são muito mais reativas porque há mais átomos por unidade de superfície.

O que é nano pode ser bom

Novos materiais e novos produtos

Nanociências + tecnologias = Nanotecnologias

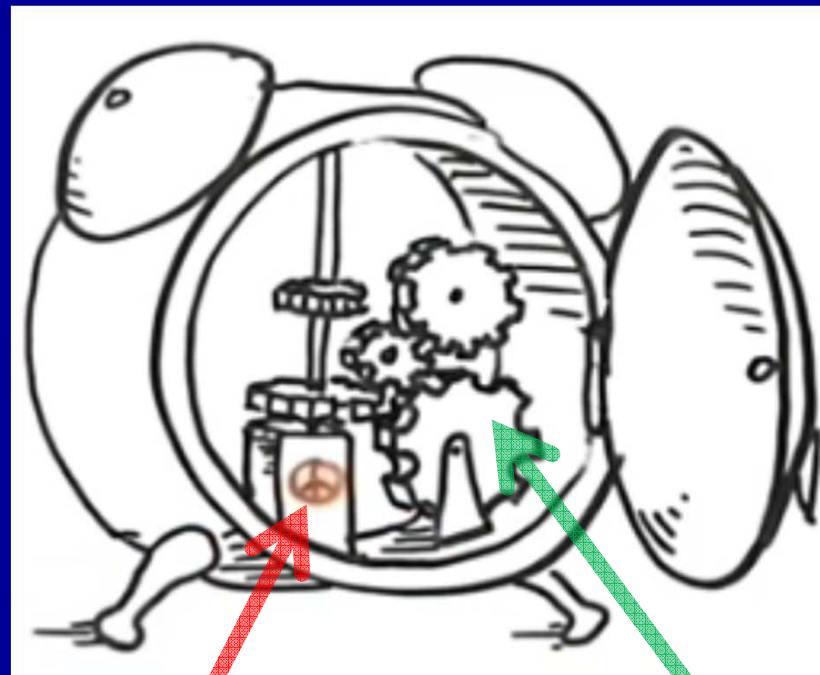
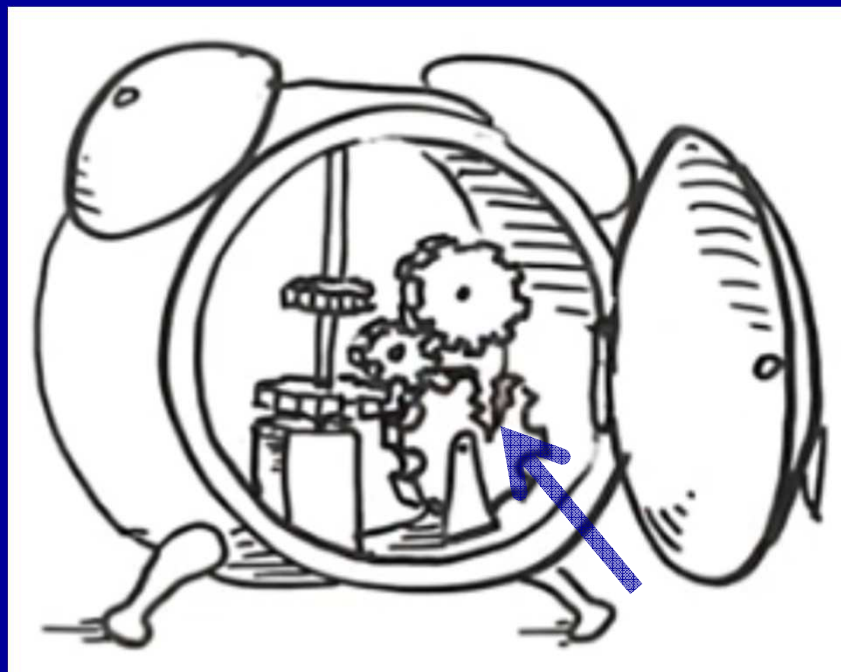


- Novas funcionalidades
- Mais rápidos
- Mais leves
- Ocupem pouco espaço e cabe em “qualquer” lugar
- Baratos
- Energeticamente mais eficientes

<http://www.youtube.com/watch?v=ITtGJUGXFKc>

Dispositivos/equipamentos com novas funcionalidades

■ Ex. capacidade de “autorreparação”



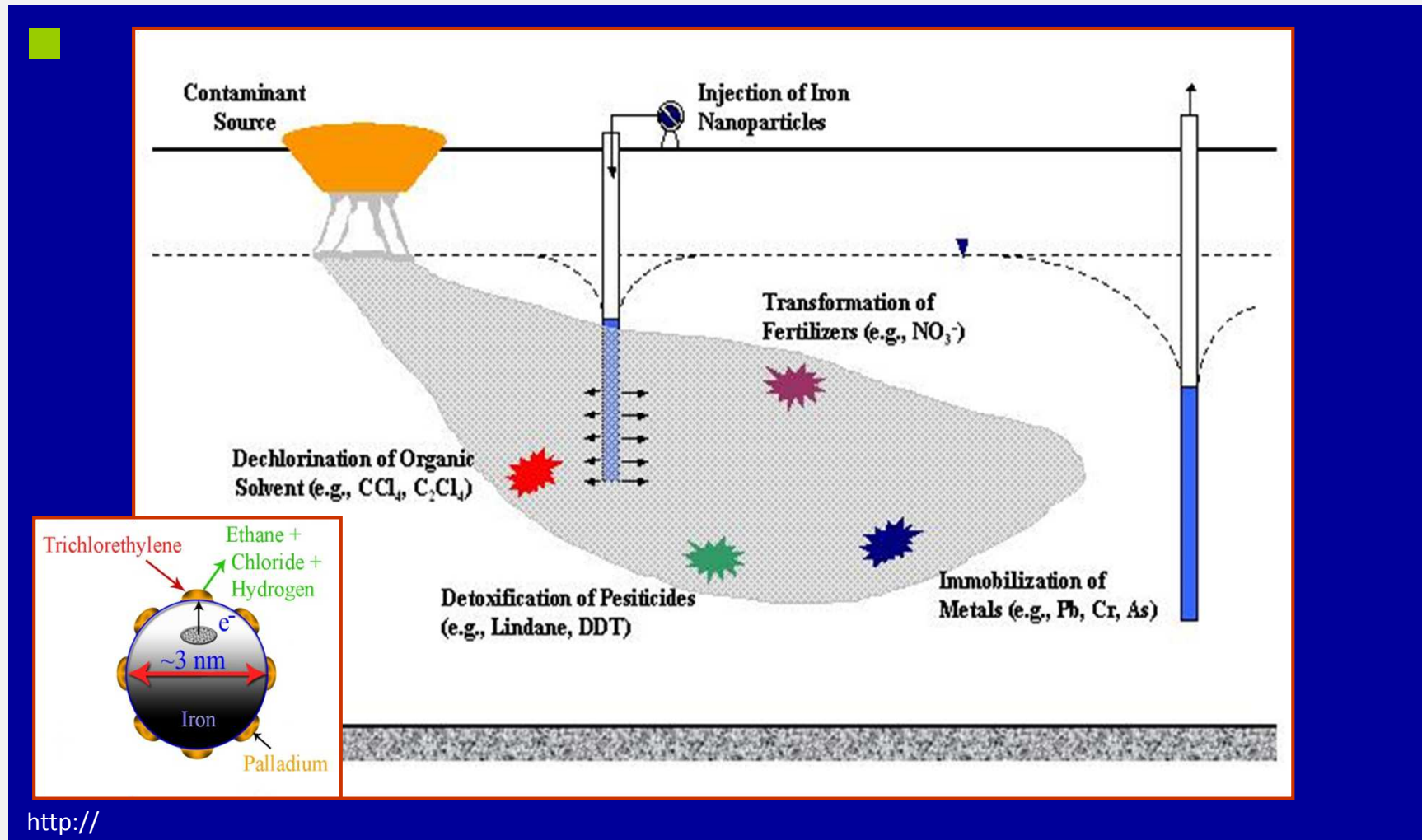
<http://www.youtube.com/watch?v=ITtGJUGXFKc>

Alimentos mais nutritivos e seguros

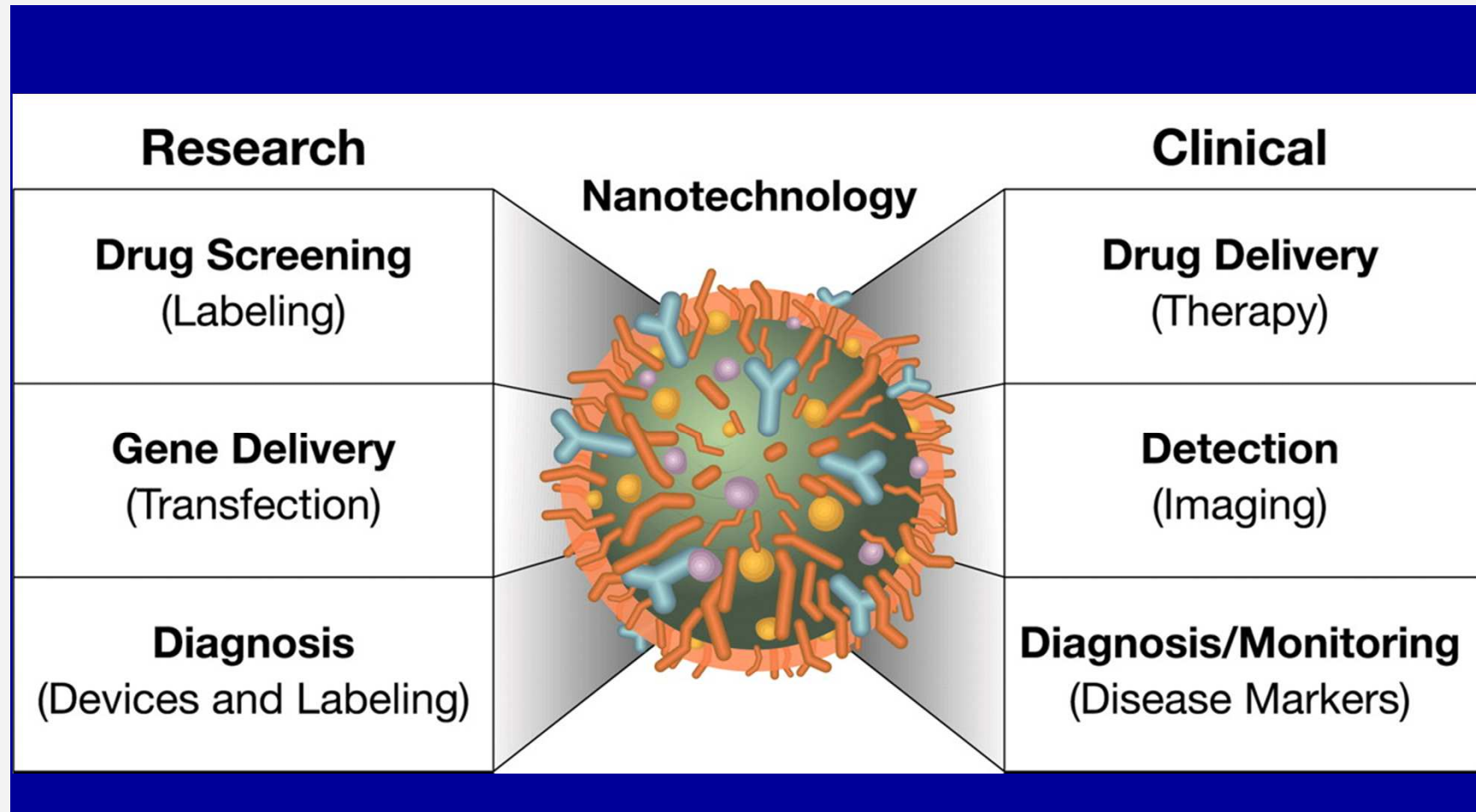


<http://www.nextnature.net/2010/05/nano-product-the-food-printer/>

Meio ambiente mais saudável



Aplicações médicas disruptivas



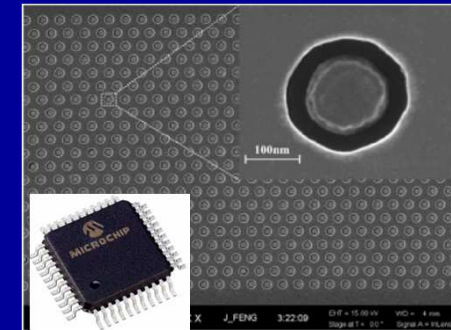
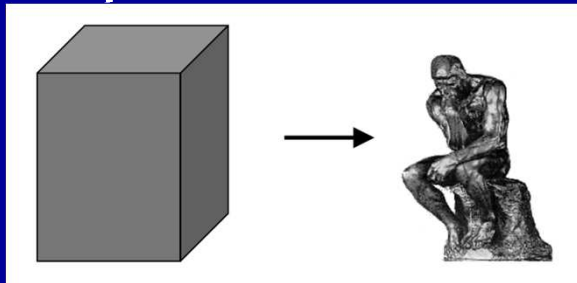
Aspetos a ter em conta

- Proteção do cérebro
- Bioincompatibilidade e toxicidade das nano-estruturas
- Segurança (pessoal, ambiental, etc.)
- Protecção do meio ambiente
- Nanopoluição/nanocontaminação (atmosférica, recursos hídricos e freáticos, cadeia alimentar, etc.)
- Implicações socioeconómicas

Abordagens e ferramentas

Abordagens da nanotecnologia

■ “top-down”



■ “bottom-up”



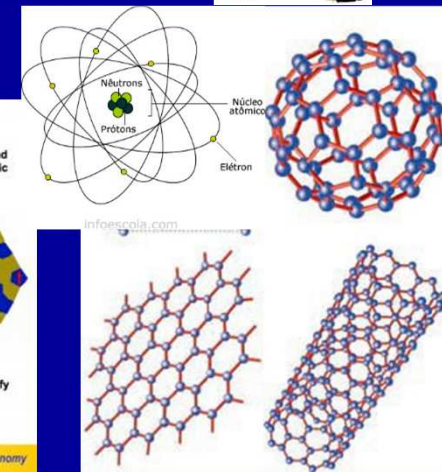
Bottom-up Fabrication of Nanocomposite Magnets

- Assembling a nanocomposite magnet from individual high-magnetization and high-coercivity nanoparticles critically depends on availability of anisotropic (single crystal) hard magnetic nanoparticles.

- Anisotropic RE-Co nanoparticles produced via surfactant-assisted HEBM satisfy the major requirements for this application.
- The next generation magnets are expected to have $(BH)_m > 100$ MGOe

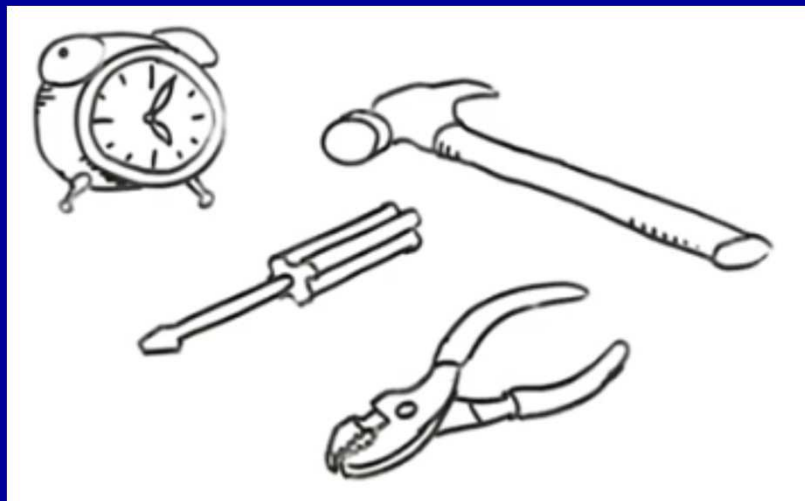
UNIVERSITY OF DELAWARE
Department of Physics & Astronomy

Carbono



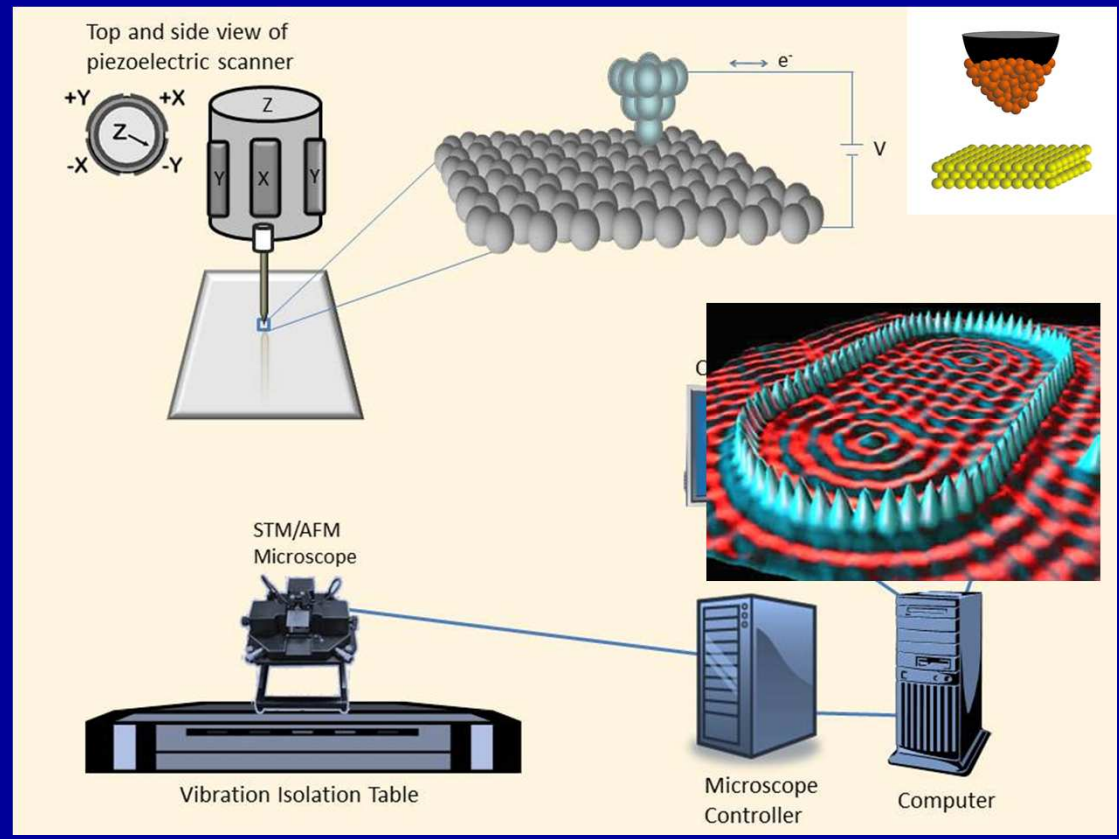
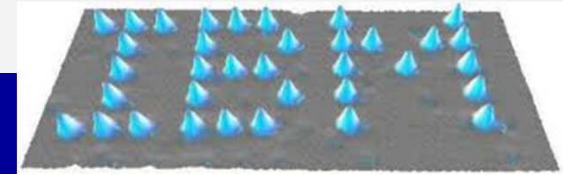
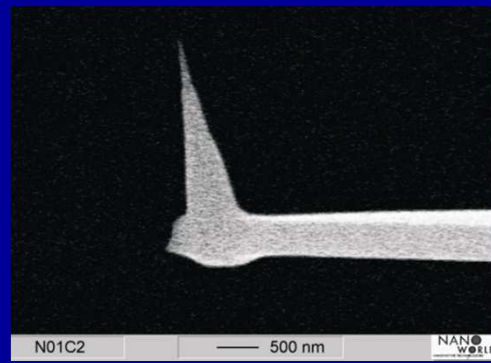
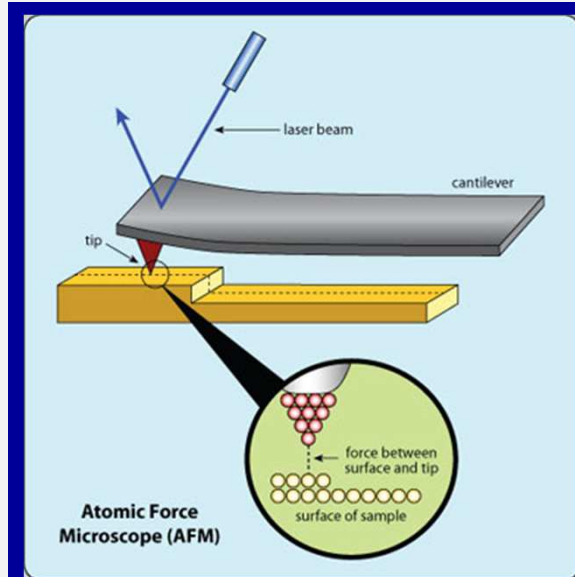
O mundo nano exige novas ferramentas

Mundo macro: ferramentas macro



<http://www.youtube.com/watch?v=ITtGJUGXFKc>

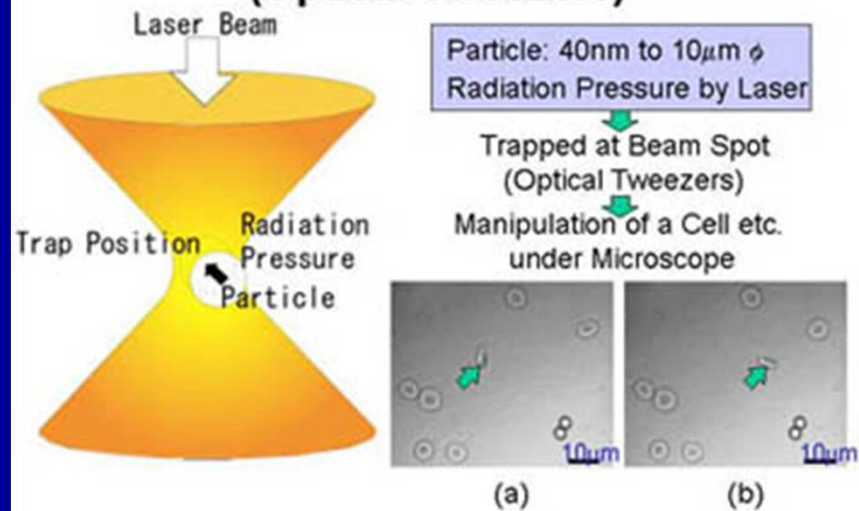
Microscópio de força atômica



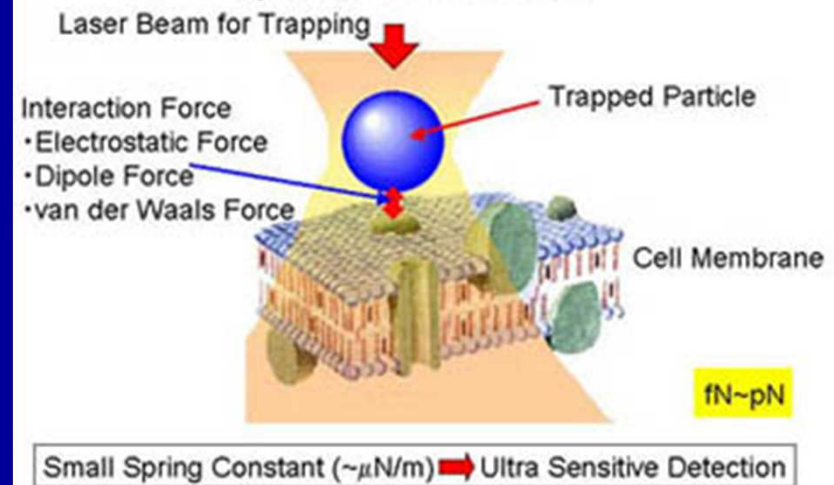
<http://www.youtube.com/watch?v=ITtGJUGXFKc>

Pinças ópticas

Trapping by Laser Radiation Pressure (Optical Tweezers)

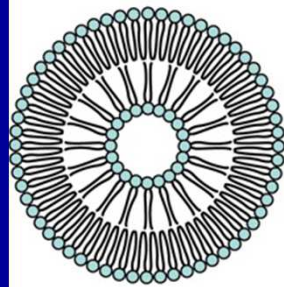


fN Force Measurement with Optical Tweezers

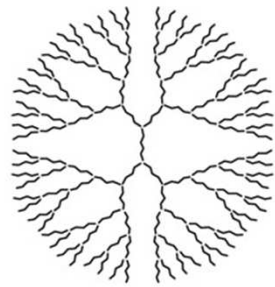


<http://kotaro.naist.jp/english/research/>

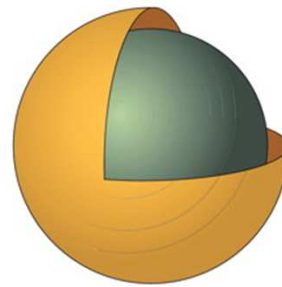
Nanopartículas



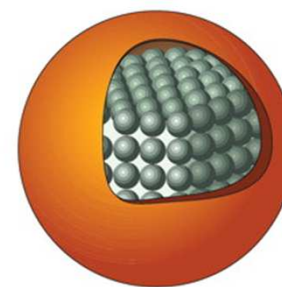
Liposome



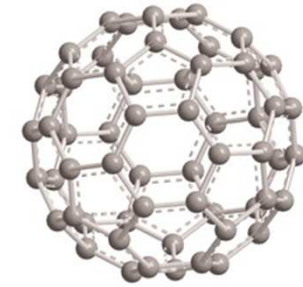
Dendrimer



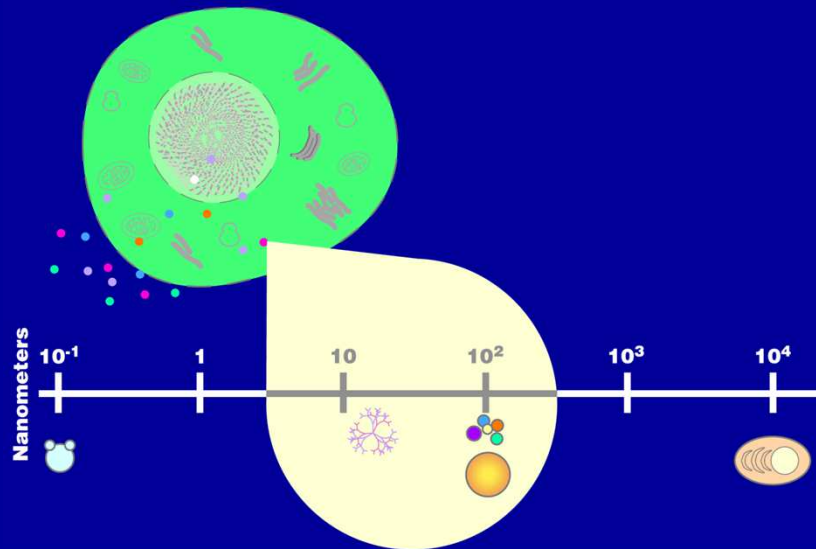
Gold Nanoshell



Quantum Dot

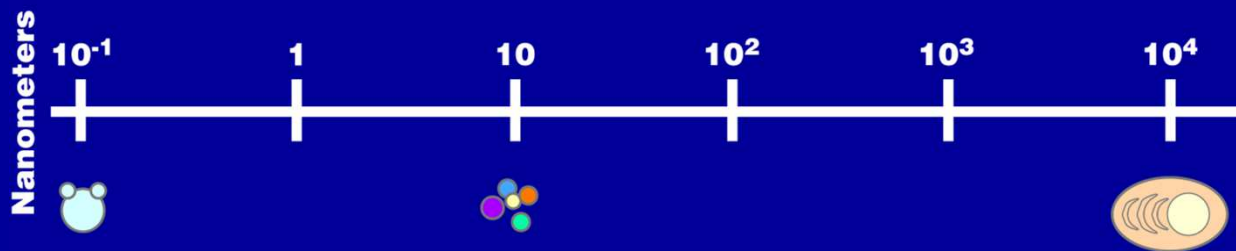
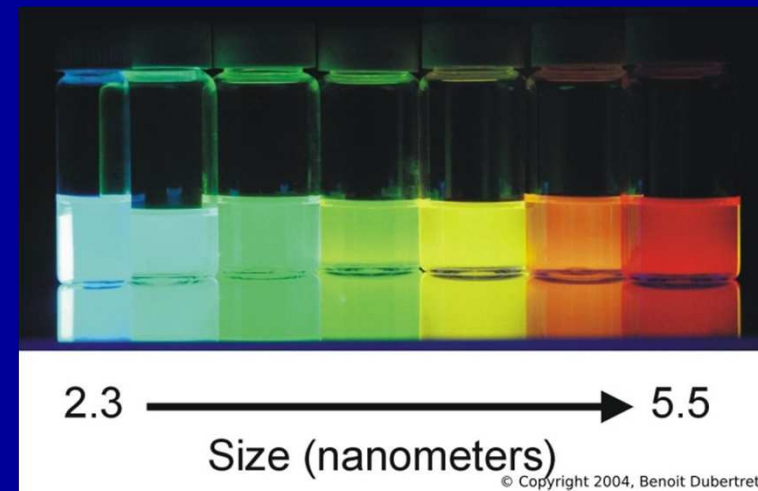
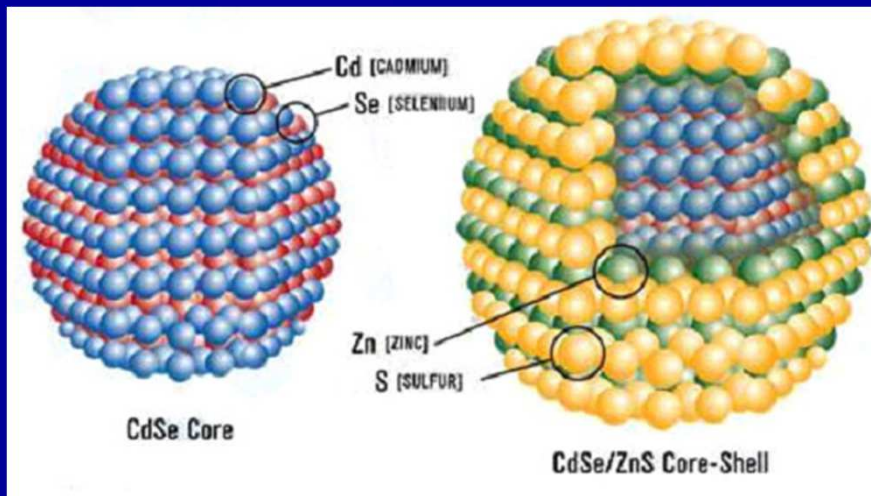


Fullerene

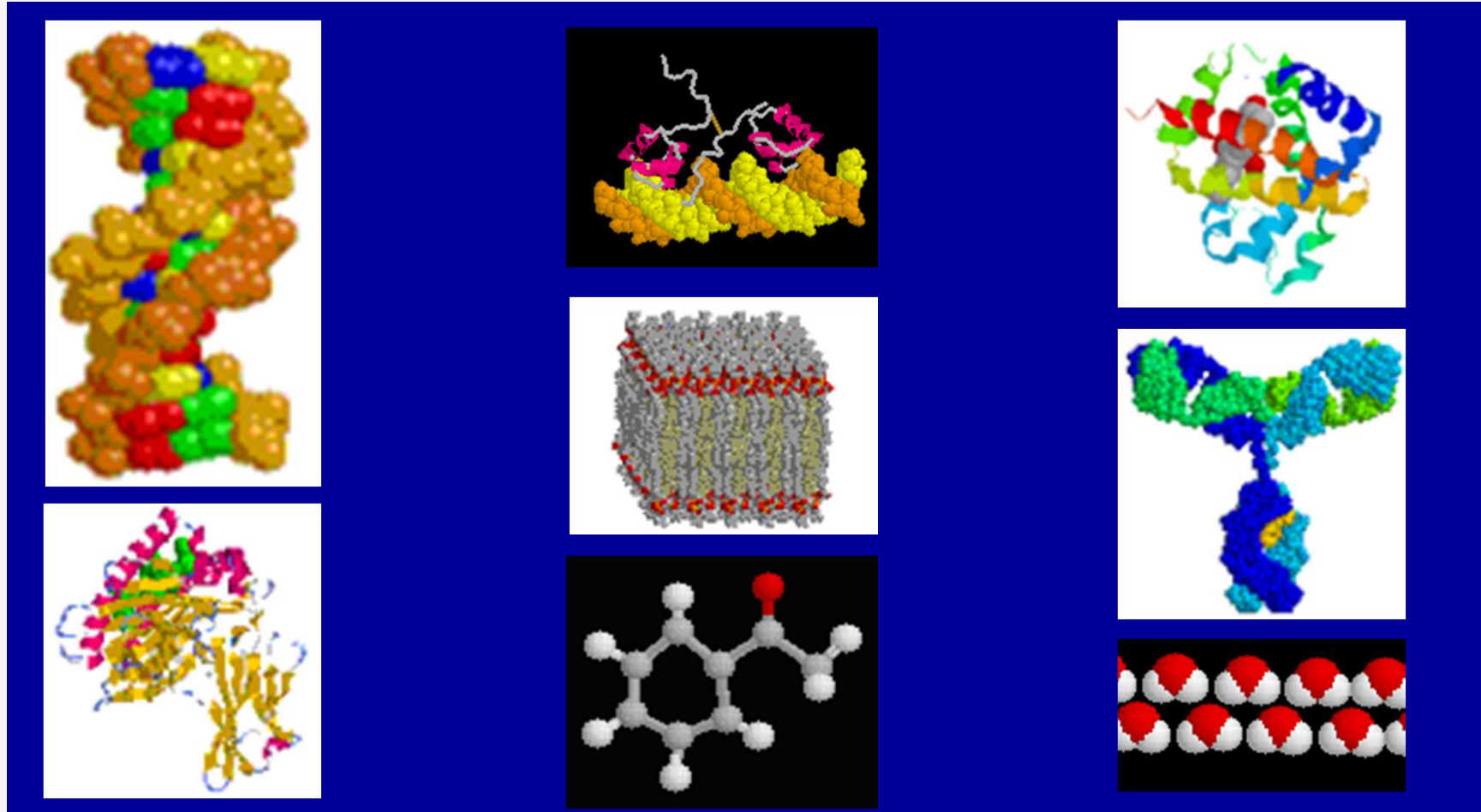


Pontos quânticos (quantum dots)

Quantum dot



Máquinas moleculares



<http://www.youtube.com/watch?v=YdjERhTczAs>



<http://w3.ualg.pt/~jlongras/nanomedicina/>

Matéria orgânica à escala macroscópica

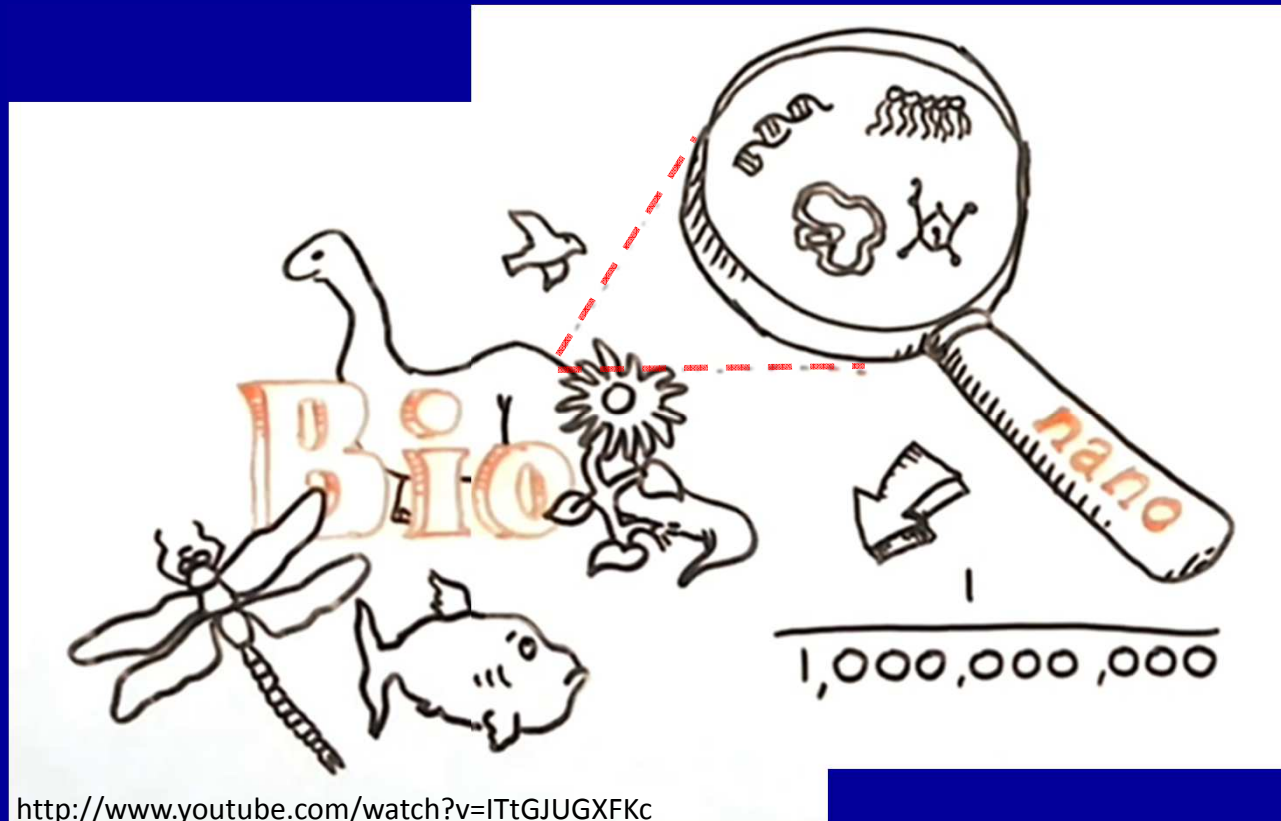


Todos diferentes ...

<http://www.youtube.com/watch?v=ITtGJUGXFKc>

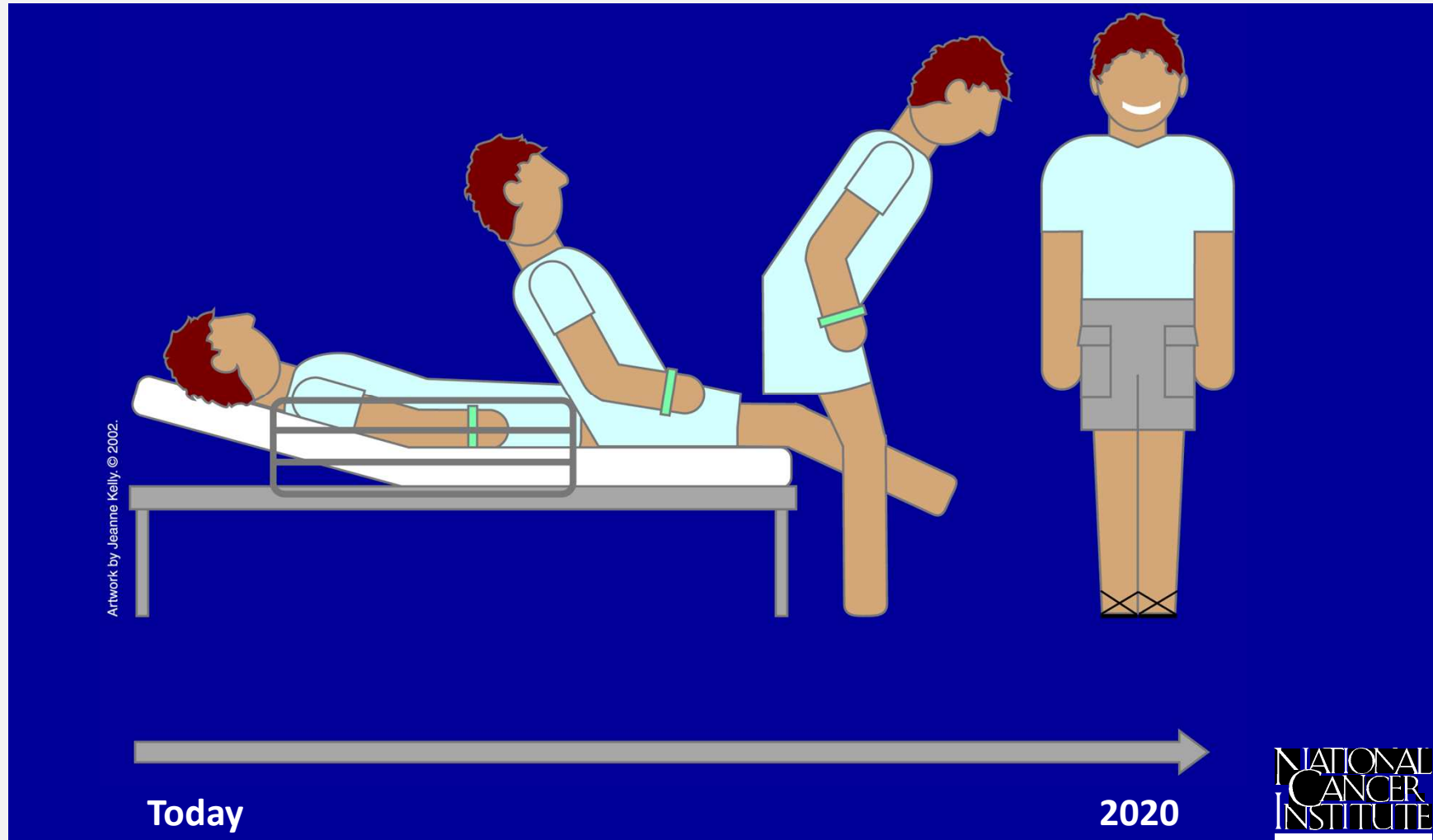
IV Encontro de Saúde da ESSUAlg, 9 de Março de 2012

... à escala nanoscópica

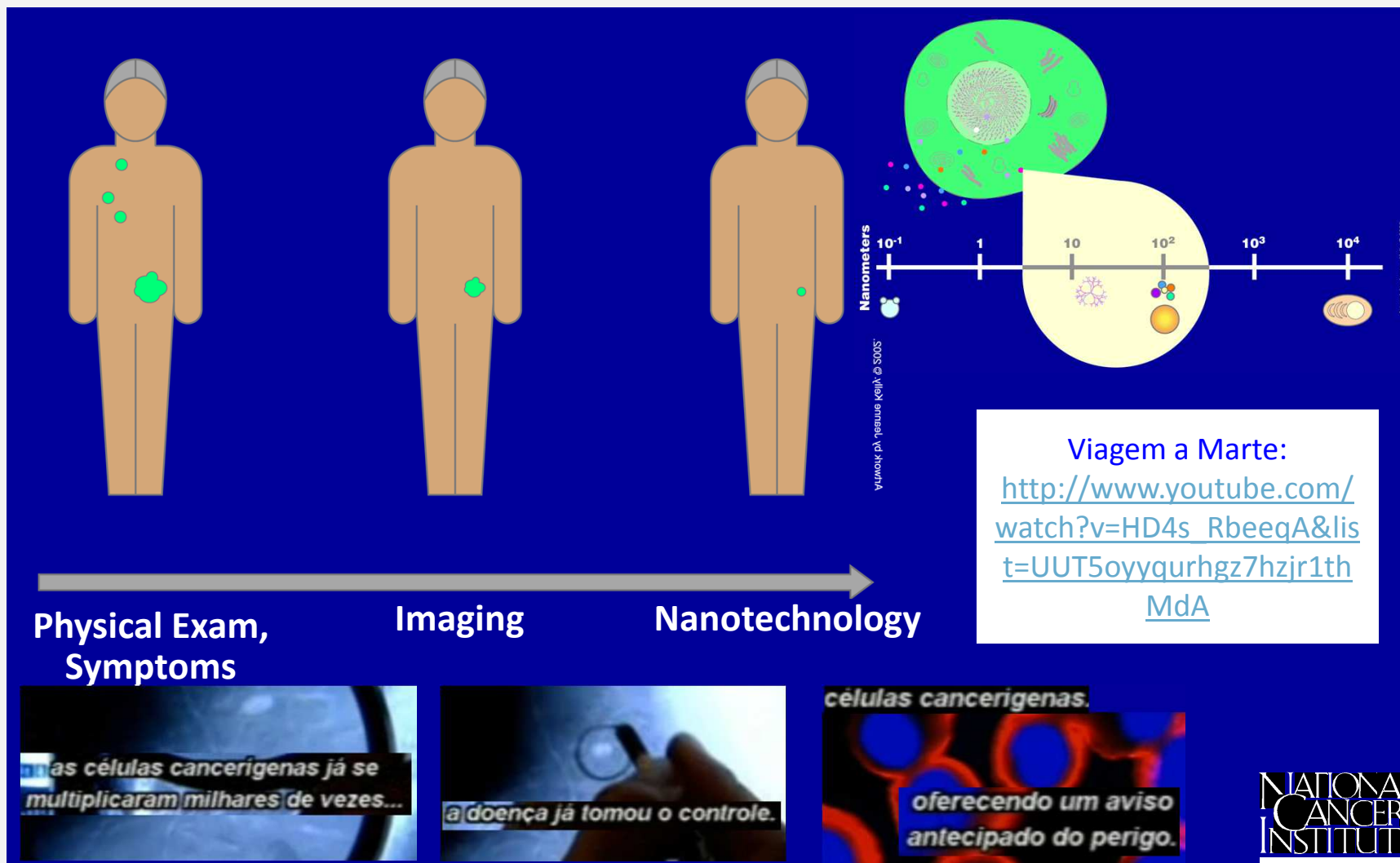


... todos muito parecidos!

Objectivo: melhores níveis de saúde publica



Detecção, diagnóstico e tratamento precoces

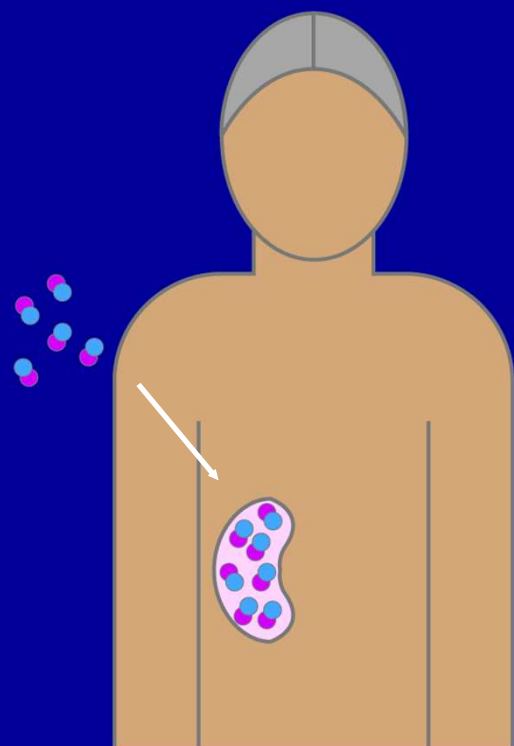


Viagem a Marte: http://www.youtube.com/watch?v=HD4s_RbeeqA&list=UUT5oyyqurhg7hzjr1thMda

IV Encontro de Saúde da ESSUAig, 9 de Março de 2012

Desenvolvimento de nanofármacos

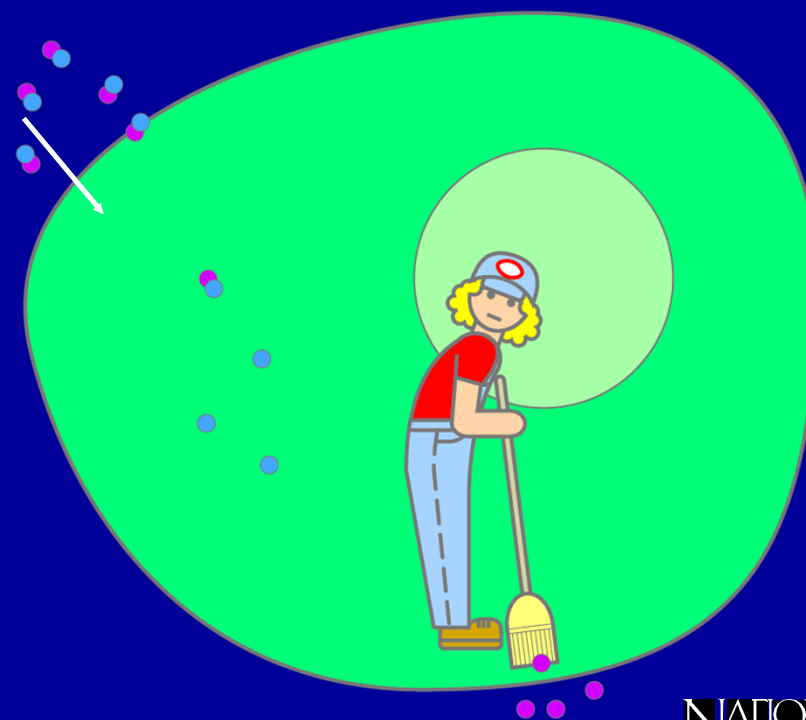
Tratamento tradicional



Artwork by Jeanne Kelly. © 2002.

Acumulação em órgãos vitais

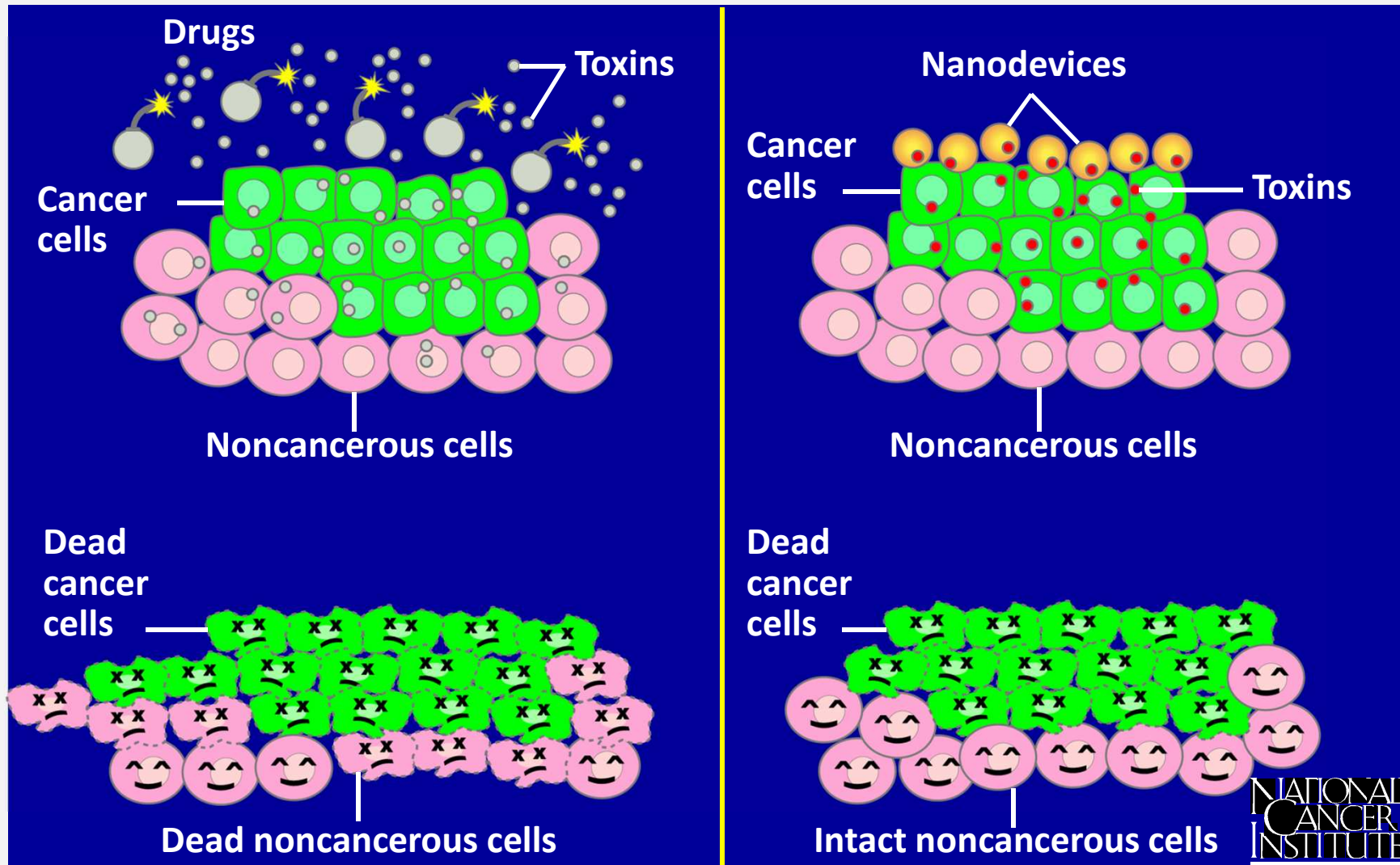
Tratamento nanotecnológico



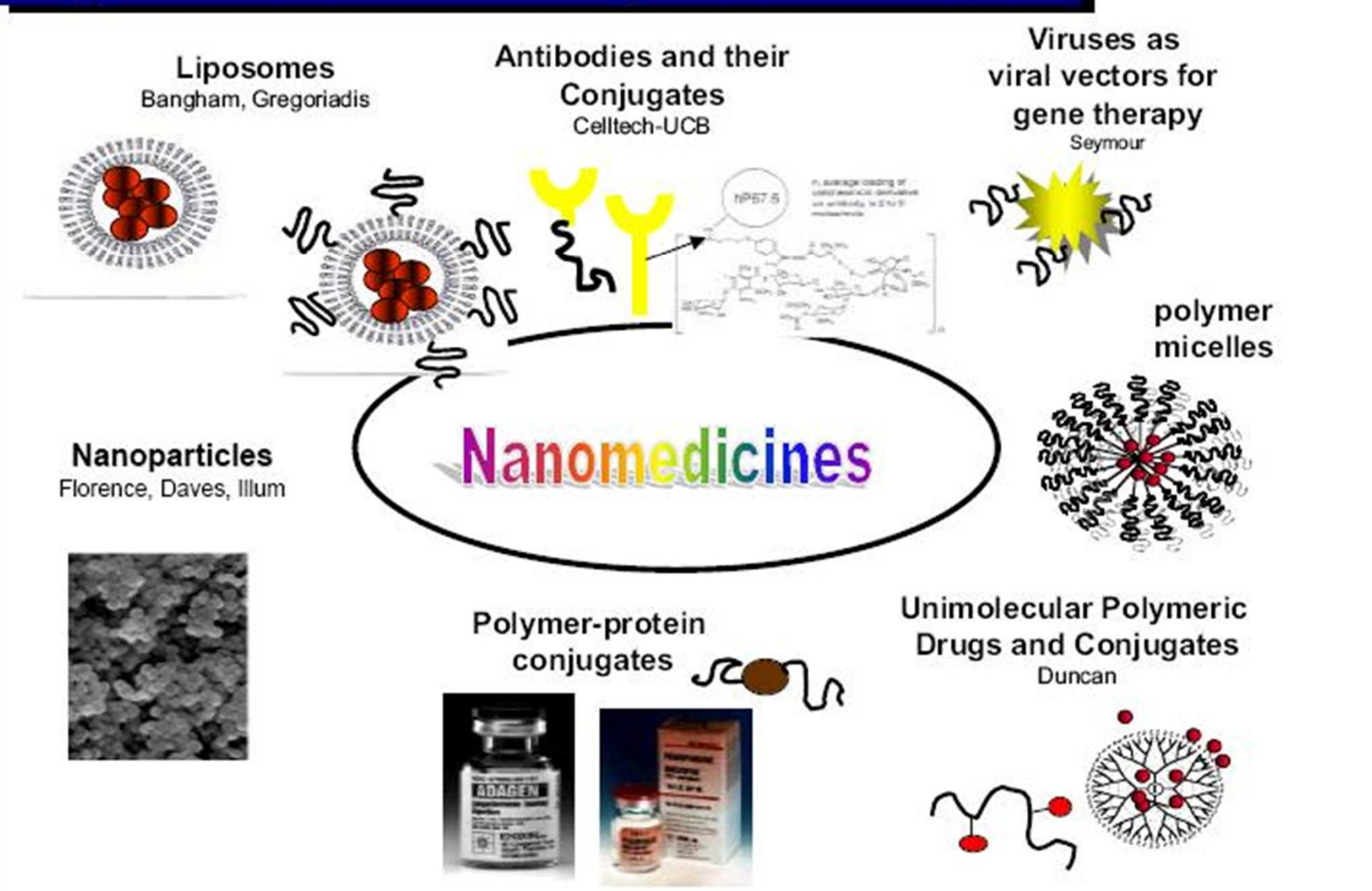
Facilmente elimináveis

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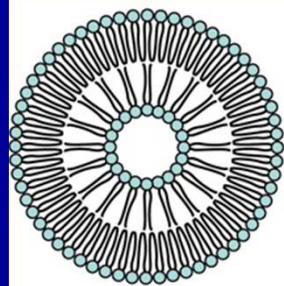
O tratamentos tradicional e o nanotecnológico



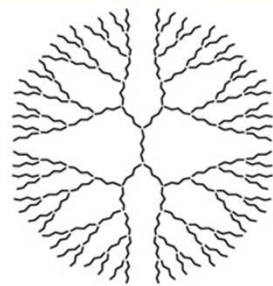
Many "Nanomedicines" are already in routine clinical use



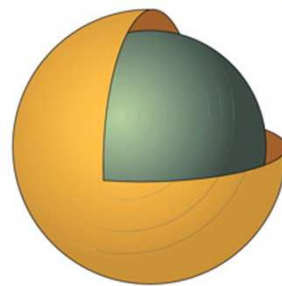
Nano-partículas *funcionalizadas*



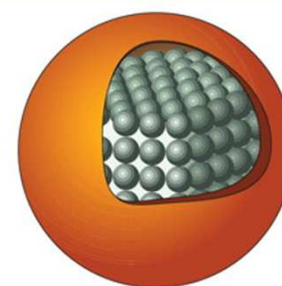
Liposome



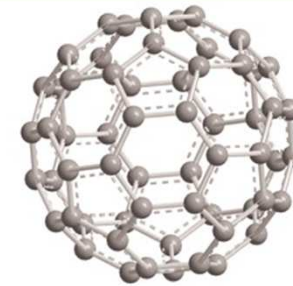
Dendrimer



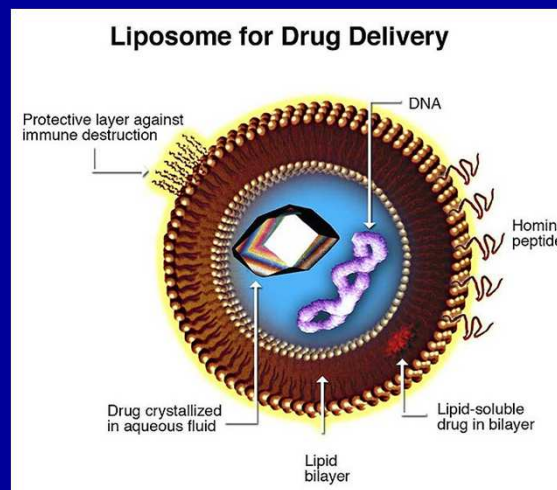
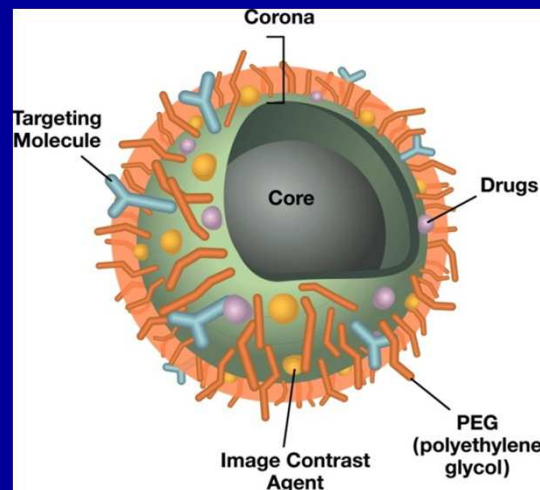
Gold Nanoshell



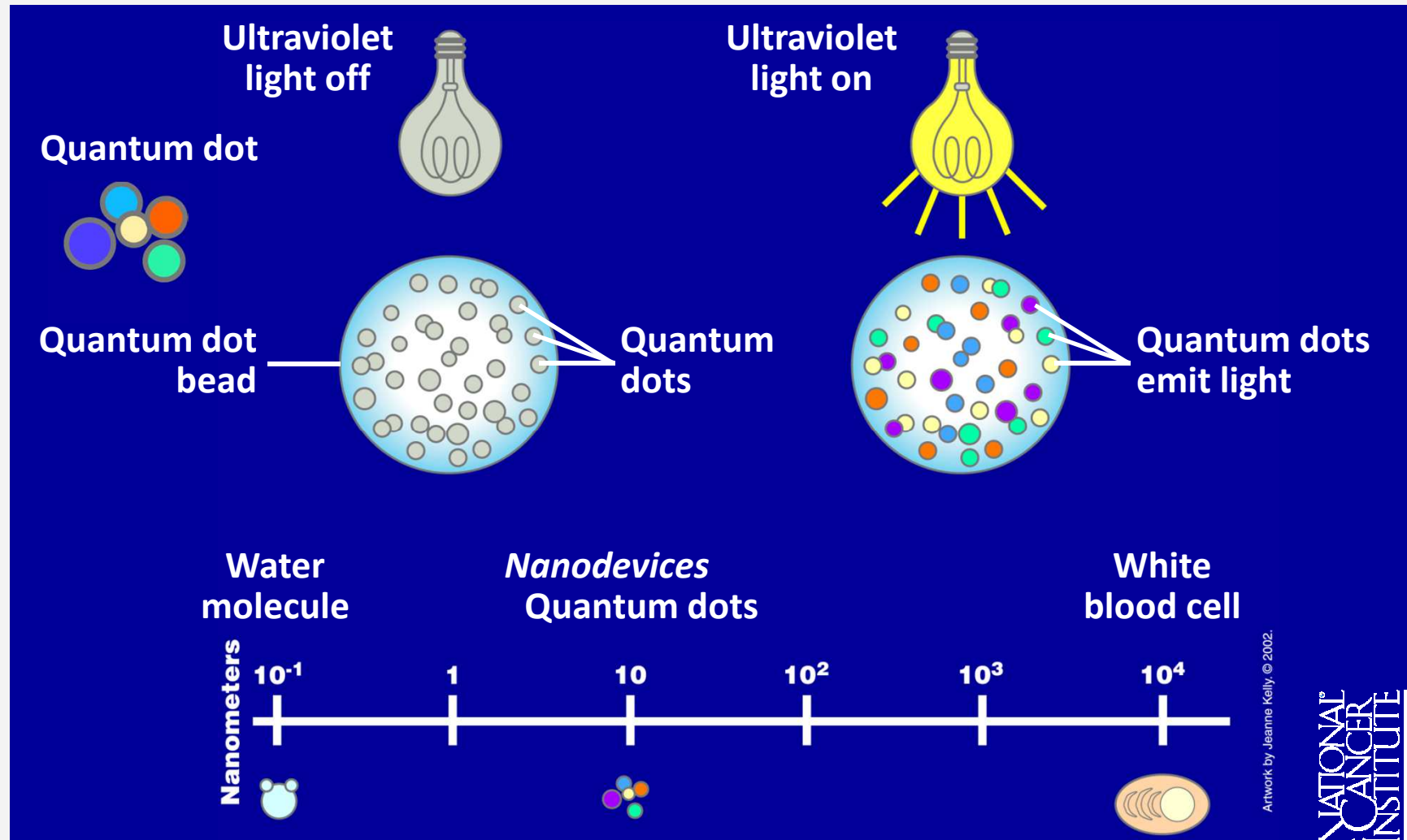
Quantum Dot



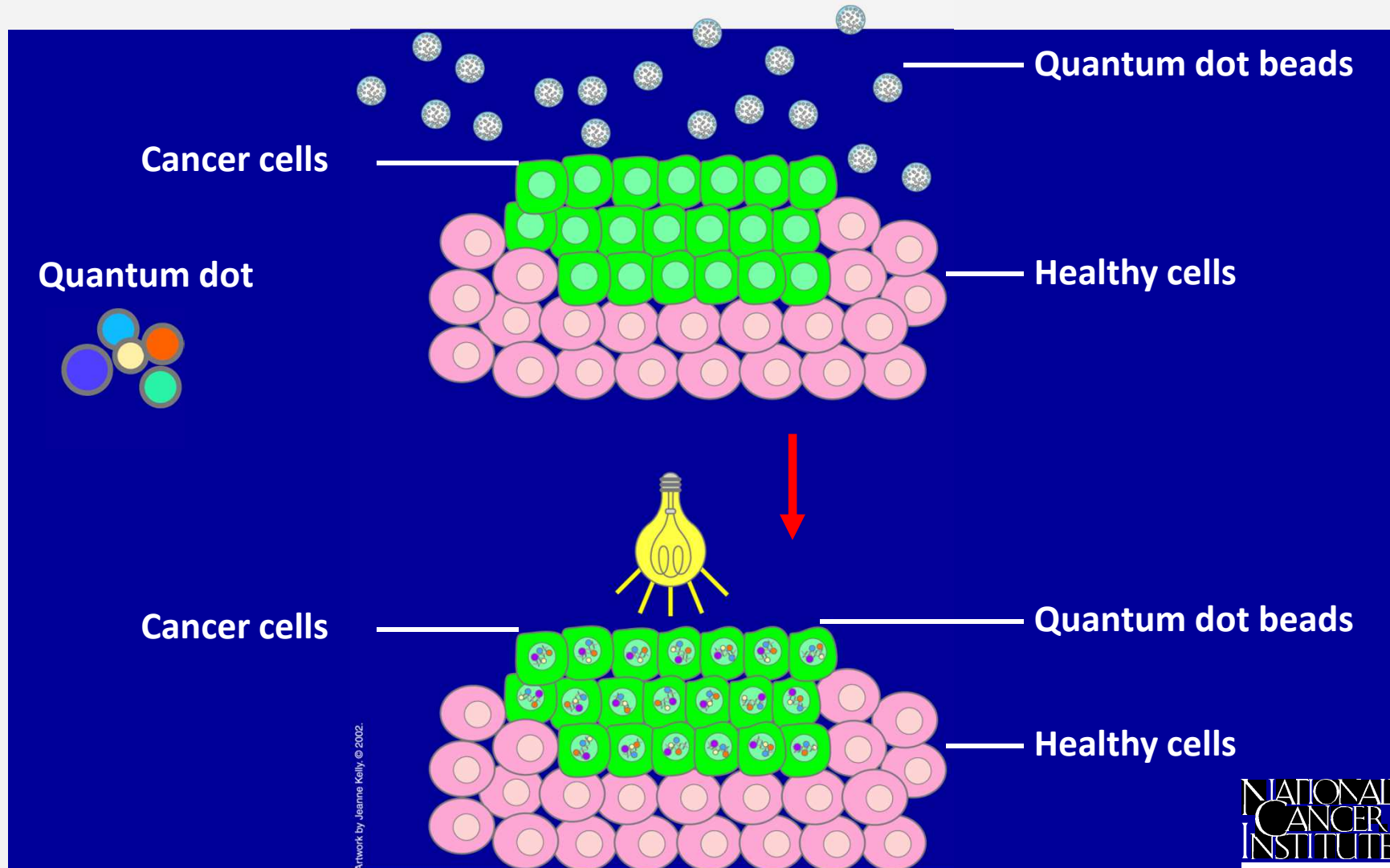
Fullerene



Aplicação de pontos quânticos como fluoróforos



Aplicações: deteção de assinaturas de doença



Aplicação: localização de tumores

Quantum dot

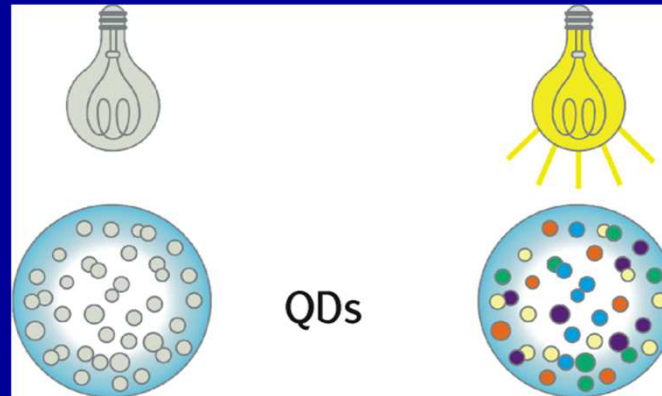
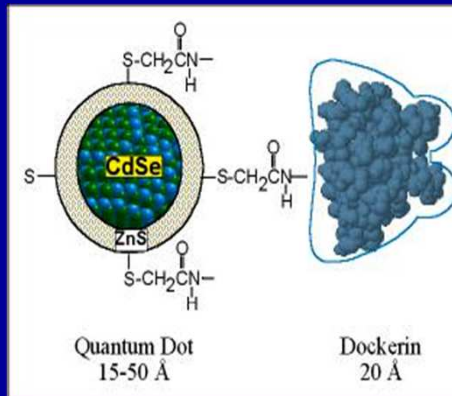
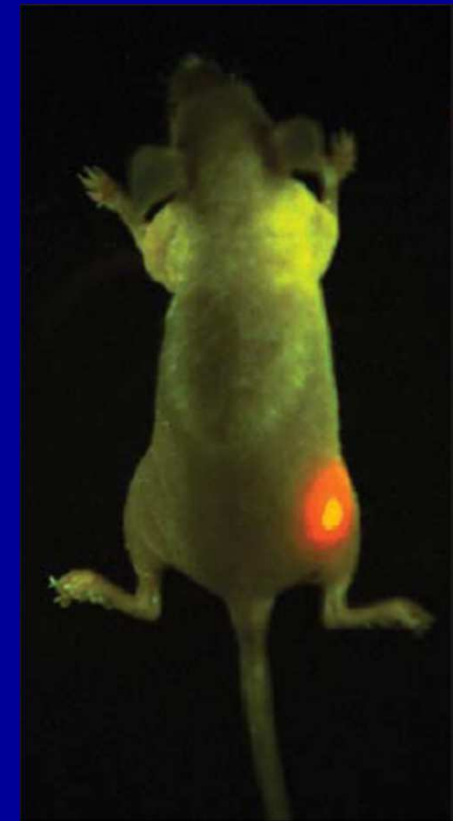


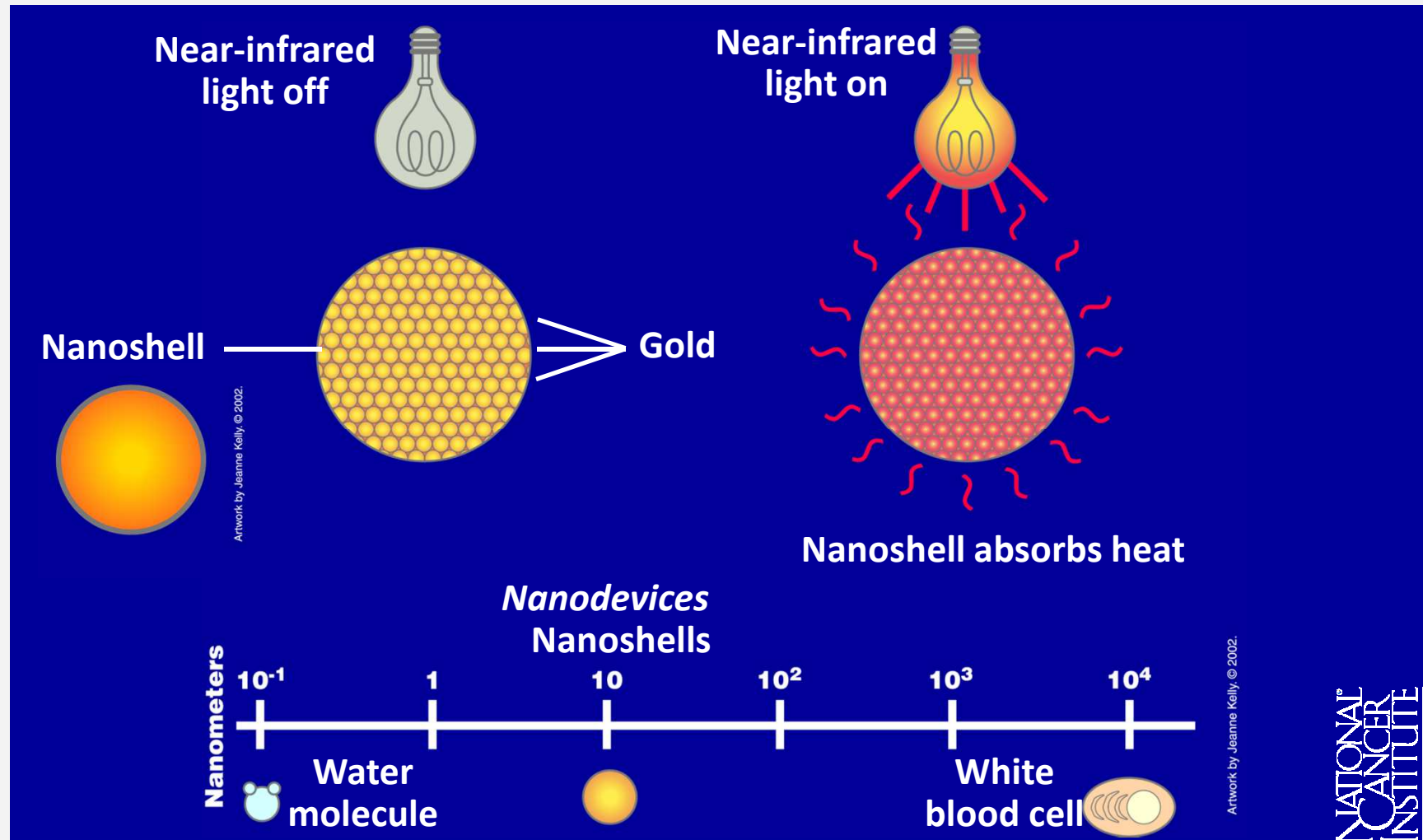
Foto: F. Fraenkel, MIT
Grupo de M. Bawendi, MIT

<http://w3.ualg.pt/~jlongras/ocancro-e-quantum-dots.wmv>

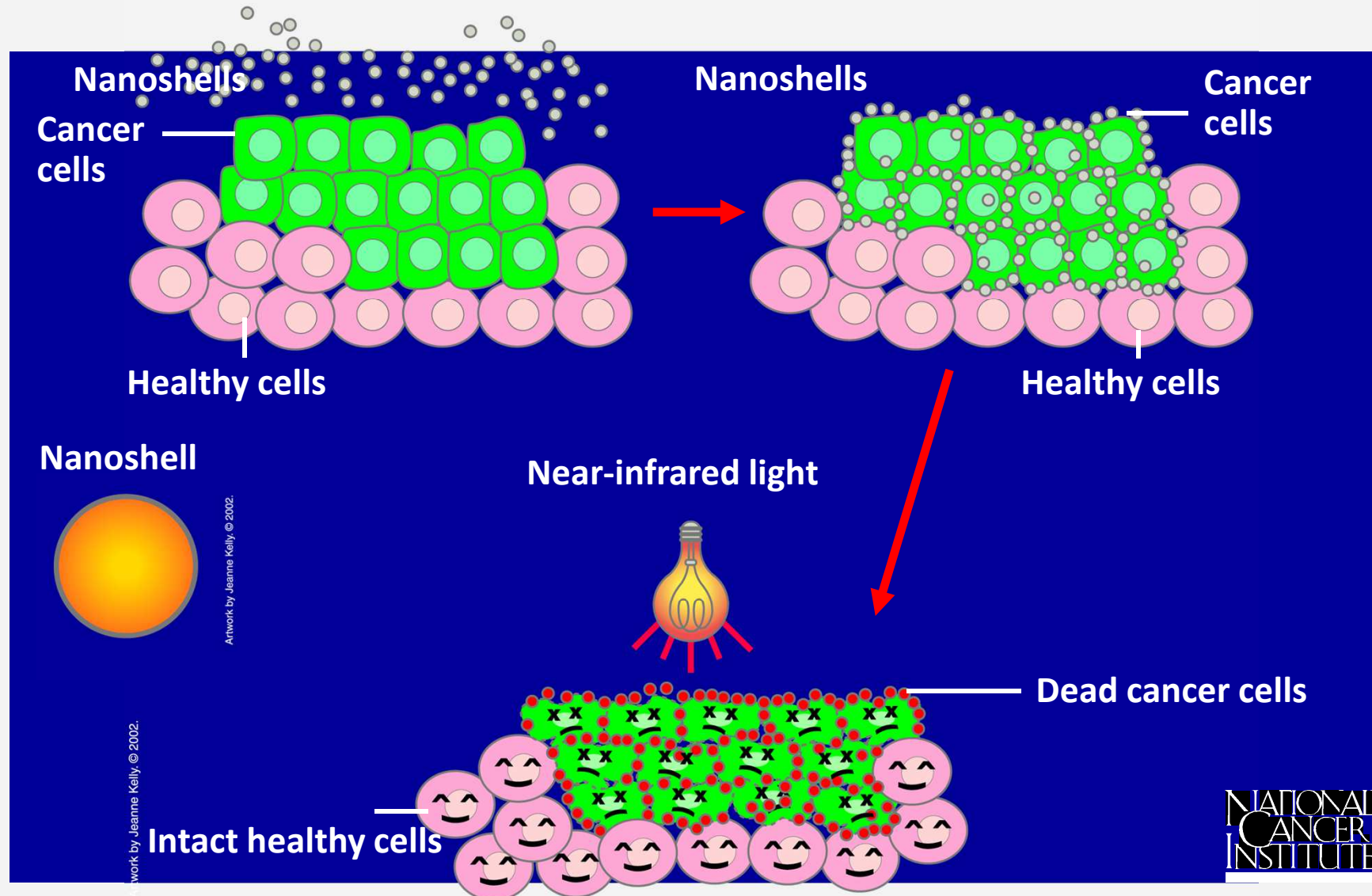


Bull's-eye. Red quantum dots injected into a live mouse mark the location of a tumor.

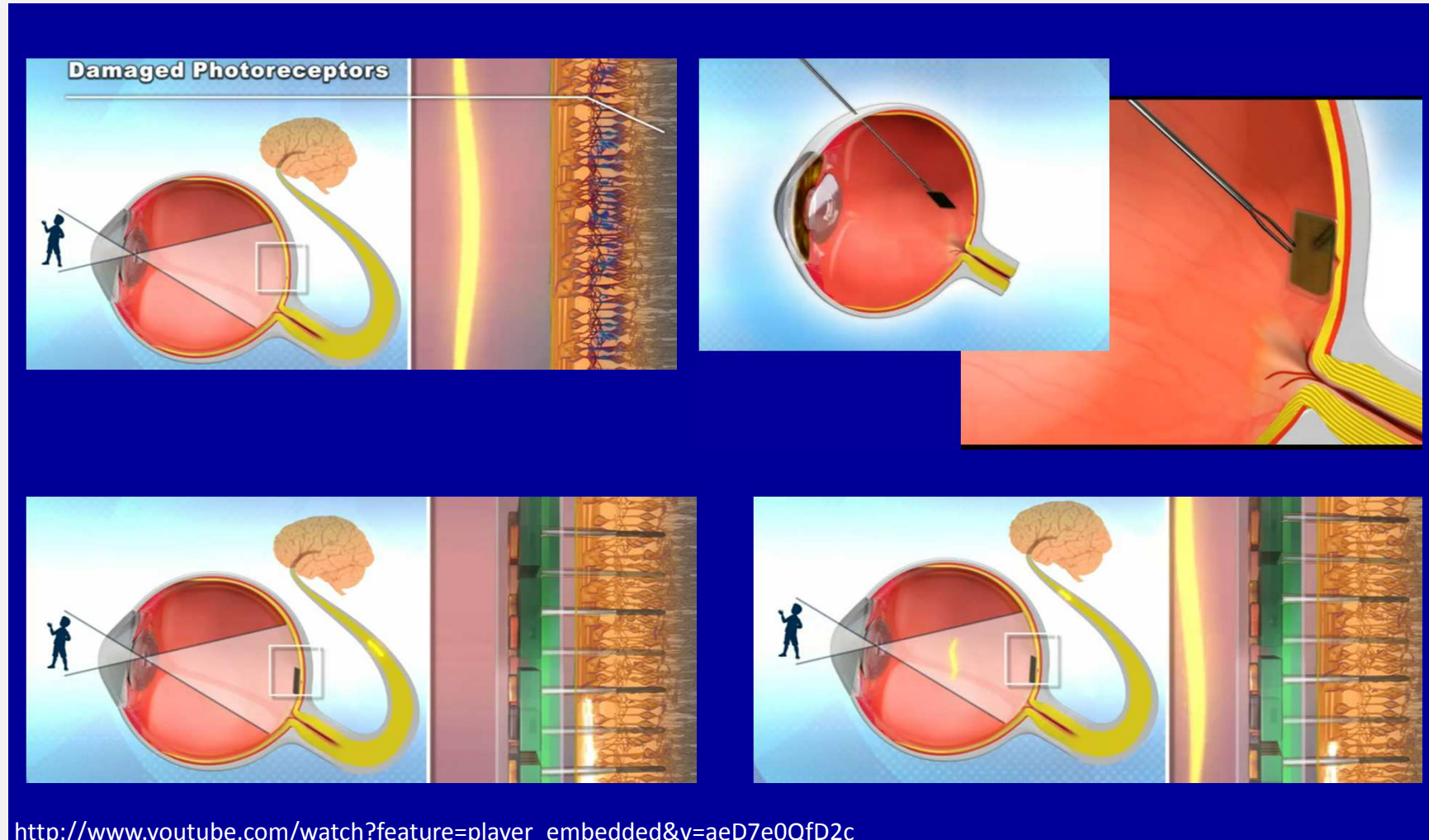
Nanopartículas metálicas



Aplicações: Eliminação de tumores

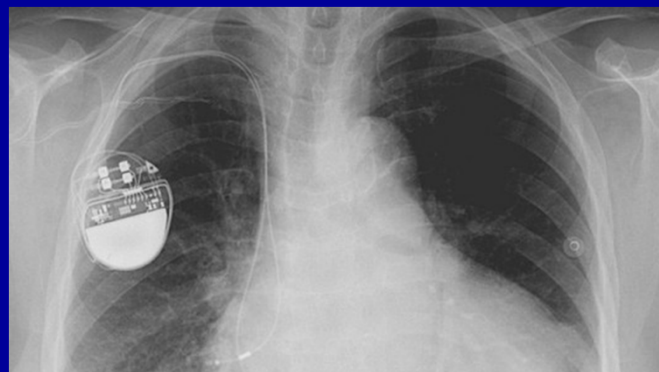


Nanoimplantes

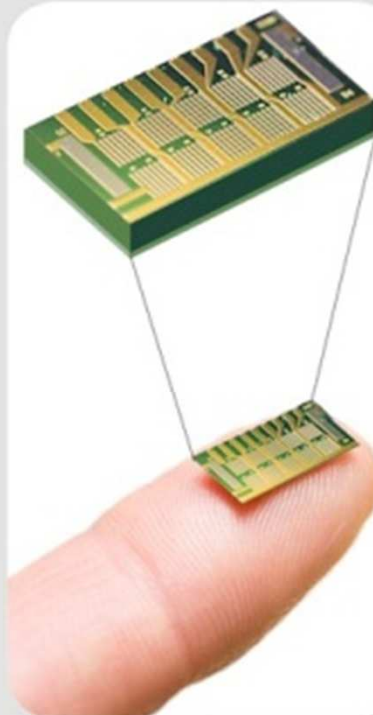


http://www.youtube.com/watch?feature=player_embedded&v=aeD7e0QfD2c

Implantes com *microchips*

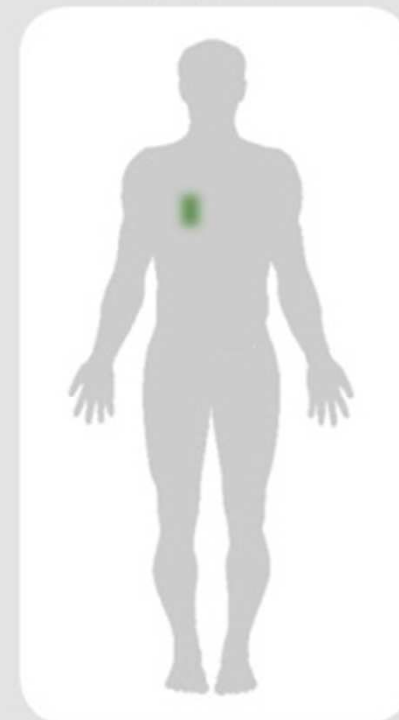


THE FIRST DRUG DELIVERY MICROCHIP



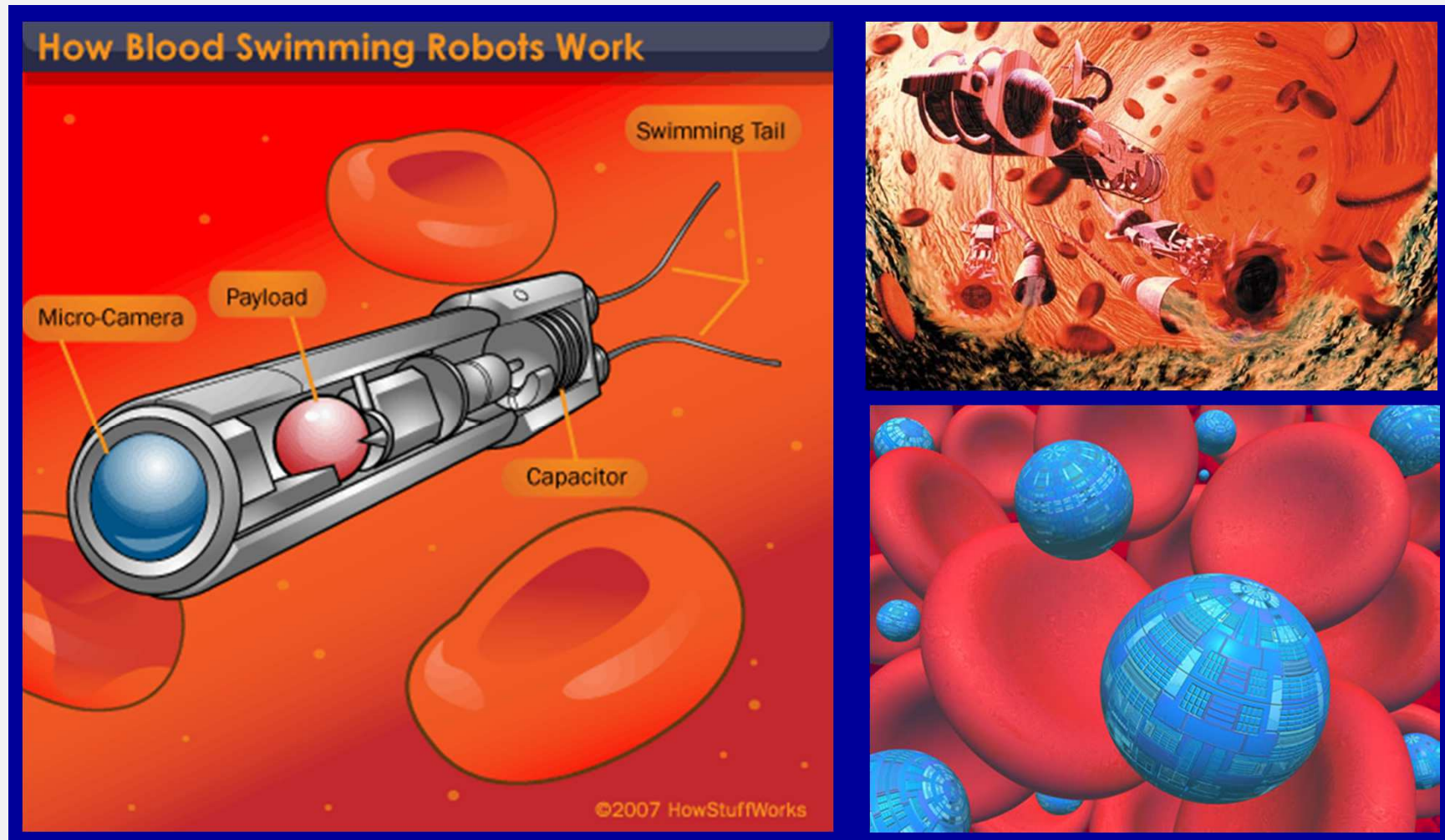
Microchip-based implant wirelessly programmed to release drugs inside the body.

DEVICE IS IMPLANTED

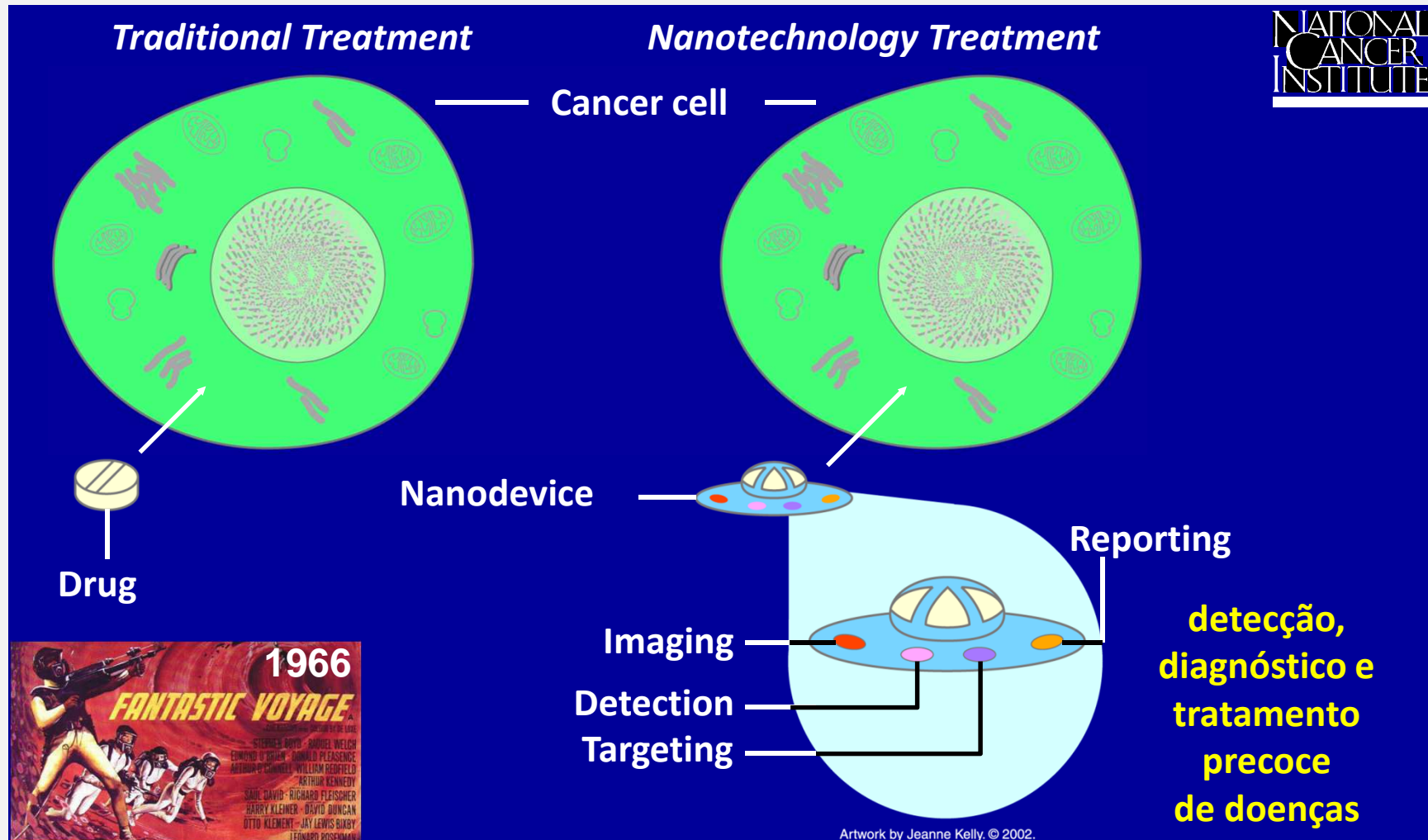


Device with microchip is implanted under skin.

Nanorobôs



Nanocirurgiões



Engolir o cirurgião

Encapsulation

SWALLOWING THE SURGEON
Nanomedicines make use of the new physical properties that materials acquire when miniaturized. With suitable tinkering, the particles can be made ready recipients for an array of molecules including: therapeutic drugs, targeting molecules for cell-specific delivery, surfactants for manipulating the shape of the particle and keeping it in solution, and imaging molecules that track the location of particles in patients.

MIX AND MATCH
There is an almost endless variety of nanoparticles, but only a handful have found their way into biomedical applications. Particles such as quantum dots and gold nanoshells make use of their inherent physical properties once inside cells or tissues. Quantum dots can be used to light up specific tissues for surgeons, while gold nanoshells can enter cancer cells where they are selectively heated with a laser, killing tumors with high temperatures. Fullerenes and liposomes can carry cargo inside as well as on their surfaces, but fullerenes must be modified in order to stay in solution. Dendrimers take their name from their fractal-like branches of molecules, which can be built around drugs that might otherwise be insoluble.

Nanoparticles range in size from 1-100 nm

- Colloidal gold
- Gold nanoshell
- Quantum dot
- Polymer
- Nanoemulsion
- Liposome
- Dendrimer
- Fullerene
- Nanocrystal

Image contrast agent
Surfactant
Targeting molecule
Drug
Cell-penetrating peptide

Functionalized nanoparticle
Leaky blood vessel
Tumor

SMALLER IS BETTER
The blood vessels that grow throughout a tumor mass are generally leakier than vessels in the rest of the body. So researchers have designed nanoparticles just small enough to escape through those holes, targeting only the tumor tissue with drugs hitching a ride on their surfaces.

Red blood cell, diameter 8,000 nm
Nanoparticles (100 nm)

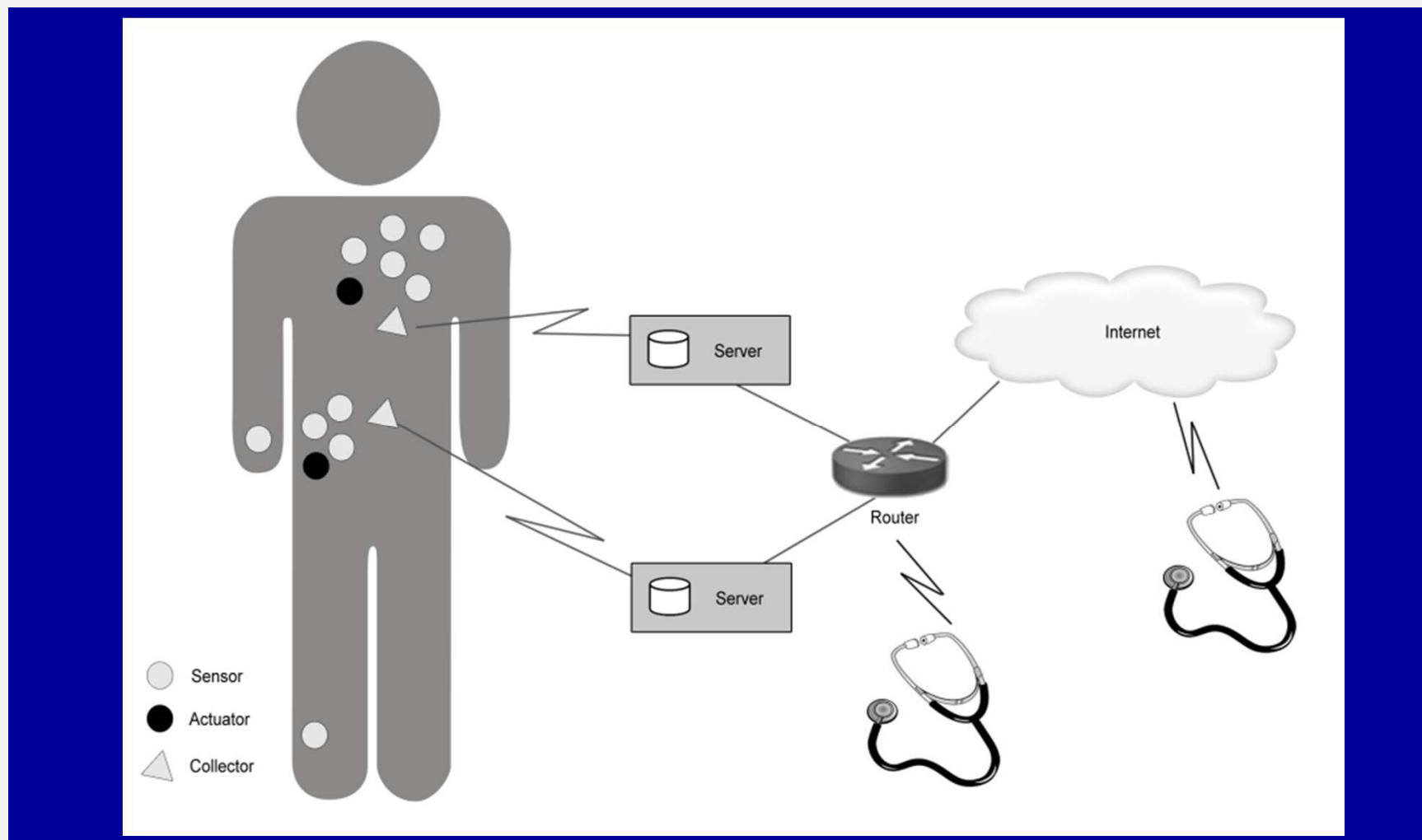
WAGENINGEN UR
The quality of life

<http://www.youtube.com/watch?v=YdjERhTczAs>

<http://www.youtube.com/watch?v=FzFY5ms3AUc>

Comunicações sem fios

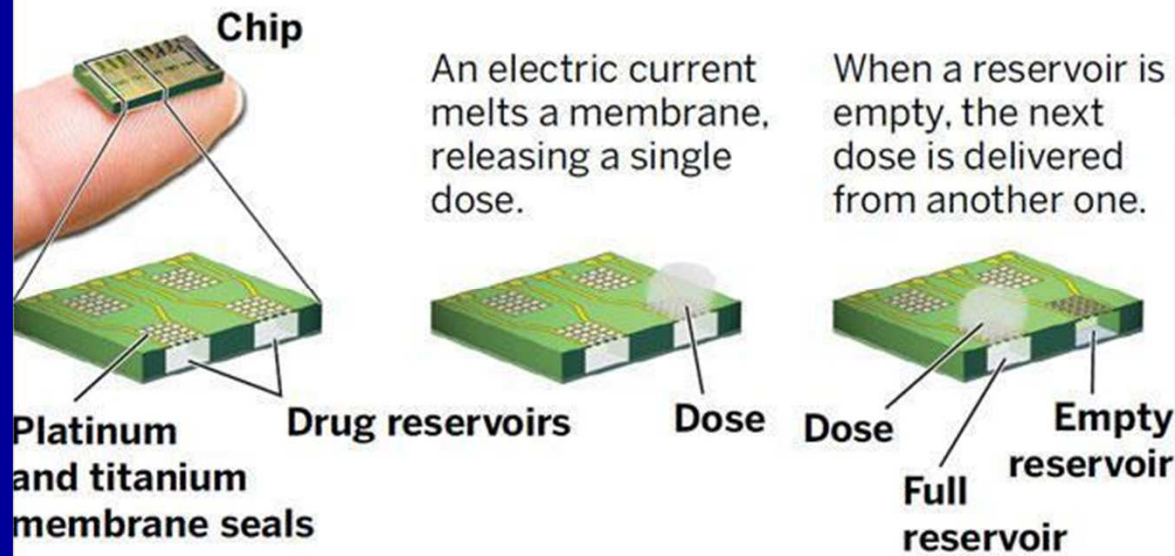
Comunicação com o exterior



Comunicação com o exterior

Wirelessly controlled drug-delivery microchip

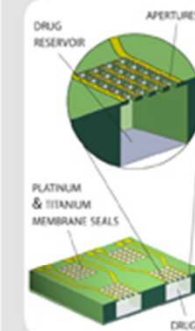
A device containing the chip, communication electronics, and a battery is implanted in the abdomen to deliver a daily dose of medicine.



SOURCE: MicroCHIPS Inc.

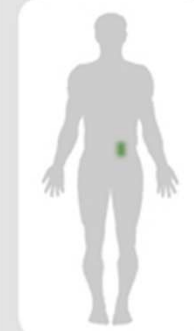
GLOBE STAFF

1. RESERVOIRS ARE FILLED WITH DRUGS



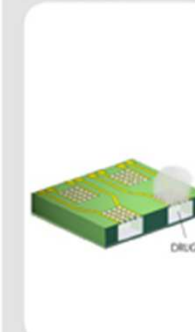
Prior to implanting, drugs are stored in an array of sealed microreservoirs.

2. DEVICE IS IMPLANTED



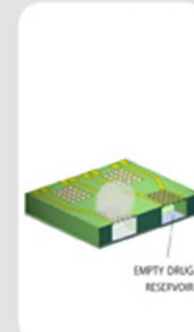
Device with microchip is implanted under skin.

4. DRUG IS RELEASED



... releasing drug from the reservoir.

5. ONGOING DRUG ADMINISTRATION



When drug reservoir is empty, the next dose can be delivered from another reservoir.



Horizon 2020

Call: H2020-ICT-2014-1

Topic: ICT-06-2014

Smart optical and wireless network technologies

Innovative ultra-BROadband ubiquitous **Wireless communications** through terahertz transceivers

Proposal acronym: iBROW

We are pleased to inform you that the aforementioned proposal has been **favourably evaluated** by the Commission. Consequently, we wish to proceed to the preparation of the Grant Agreement based on your proposal.

(4.1) EU contribution requested in Proposal: 3,995,130.00 EUR

(4.2) Maximum EU grant amount attributed to the Action following evaluation: 3,995,130.00 EUR

Referências

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- <http://pt.wikipedia.org/wiki/Nanotecnologia>
- <http://pt.wikipedia.org/wiki/Nanomedicina>
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- <http://w3.ualg.pt/~jlongras/palestras.html#nano>
- <http://w3.ualg.pt/~jlongras/Entrevista-Mundus.pdf>
- <http://w3.ualg.pt/~jlongras/Nano.swf>
- <http://w3.ualg.pt/~jlongras/Quanta.swf>
- <http://w3.ualg.pt/~jlongras/nanomedicina/>

Obrigado!