Breve historia de la Nanotecnología

Prenanotecnología

Siglo IV dC — Copa Lycurgus (antigua Roma)

Edad Media — Vidrieras de las catedrales góticas

1920 — Irving Langmuir y Katharine B. Blodgett introducen el concepto de monocapa,
Langmuir – Premio Nobel en Química

Nanotecnología

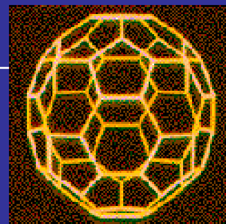
Nuevas herramientas/ Nuevos fenómenos/Nuevas aplicaciones

Breve Historia

1959 — *Richard Feynman There is plenty of room at the bottom, “Until researchers had tools sized just right for directly manipulating atoms and molecules”*

1980 — **MBE** — Capas atómicas, pozos cuánticos, Laser de semiconductor, Materiales de GMR

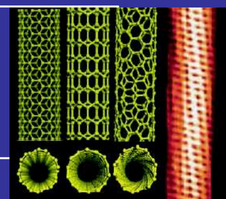
1981 — **STM** i i — Aparece la palabra nanotecnología por primera vez en un articulo científico



1985 — Fullerenos ma

1986 — **AFM**

1990 — Manipulación atómica i

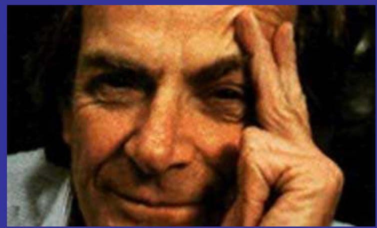


1991 — Nanotubos carbono Iijima

1999 nanotube transistor; 1999 Tour and Reed molecular electronics, 2000 Clinton iniciativa de nanociencia

Breve historia de la Nanotecnología

1959 Richard Feynman (reunión de la American Physical Society en Caltech):



"There is plenty of room at the bottom"

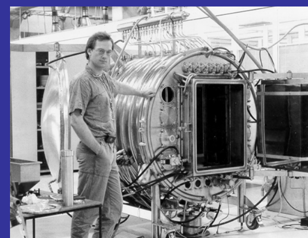
…en su discurso futurista habla sobre máquinas moleculares construidas con precisión atómica

1974 Norio Taniguchi publica ***On the Basic Concept of 'Nano-Technology'***

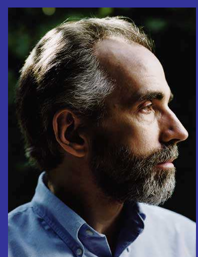
El término nanotecnología es definido por primera vez

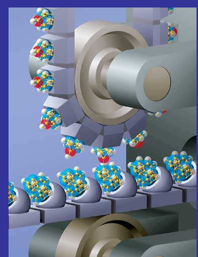
Atomic layer deposition

Dr. Tuomo Suntola y sus colaboradores consiguen la deposición de capas monoatómicas



1977 Drexler crea el concepto de nanotecnología molecular en el MIT

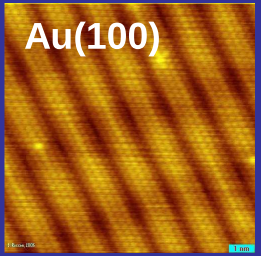


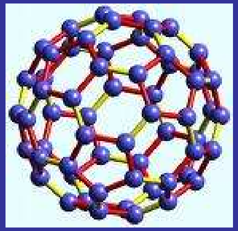


Breve historia de la Nanotecnología

1981 Se publica el primer artículo técnico sobre ingeniería molecular

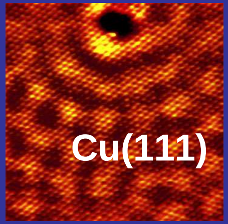
Se inventa el microscopio de efecto túnel STM
Heinrich Rorher y Gerd Binnig - P. Nobel en Física





1985 Se descubre la Buckyball: los Fulerenos entran en escena

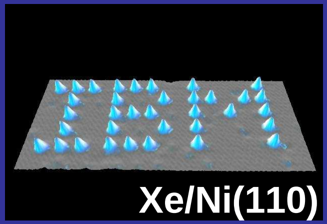
1986 Se inventa el microscopio de fuerza atómica AFM

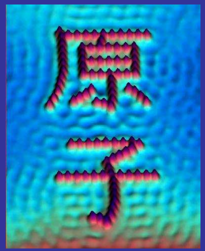


Charge density waves “vistas” con AFM

1989 La manipulación atómica es una realidad:

El logo de IBM escrito con átomos





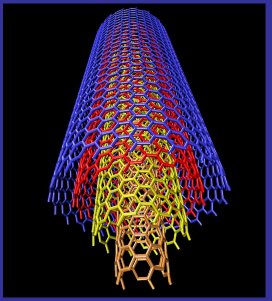
Breve historia de la Nanotecnología

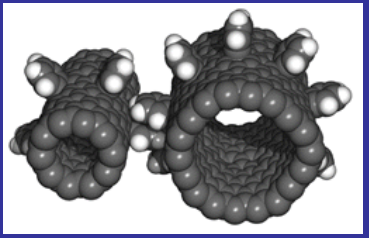
1991 El Ministerio japonés de Economía, Comercio e Industria MITI anuncia *la bottom-up "atom factory"*

IBM aprueba el plan hacia el bottom-up

El MITI aprueba $200 million en el proyecto *bottom-up*

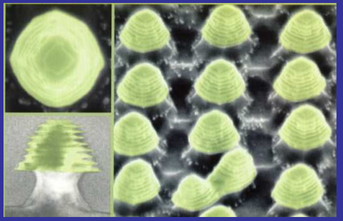
Se descubren los nanotubos de Carbono





1993 Primer informe sobre nanotecnología realizado por la casa Blanca

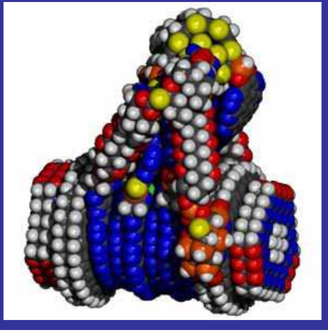
El libro "Engines of Creation" enviado a la administracion Rice, estimula la creación del primer centro de nanotecnología



MBE: Si etching of multilayer GeSi/Si islands.

1997 Se funda la primera compañía en nanotecnología: Zyvex

Diseño del primer nanorobot



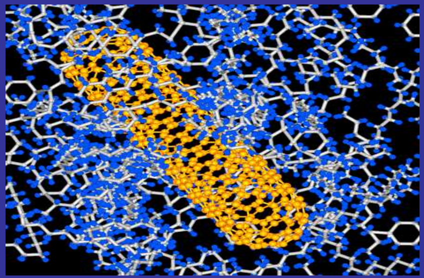
Breve historia de la Nanotecnología

2000 El presidente Clinton anuncia la *U.S. National Nanotechnology Initiative*
Primera inversión estatal en investigación: $100 million in California

2001 Primer informe sobre la industria nanotecnológica

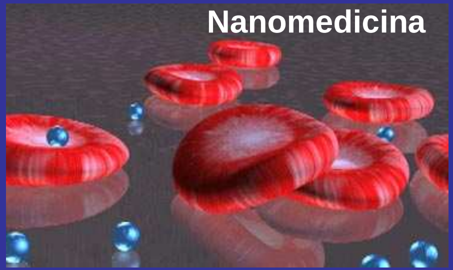
2004 Llamamiento de las Academias Americanas a la investigación experimental dirigida a la fabricación molecular

2007-… Un futuro abierto:



NASA: simulación por ordenador compuesto polímero- nanotubo de carbono

Nanorobótica



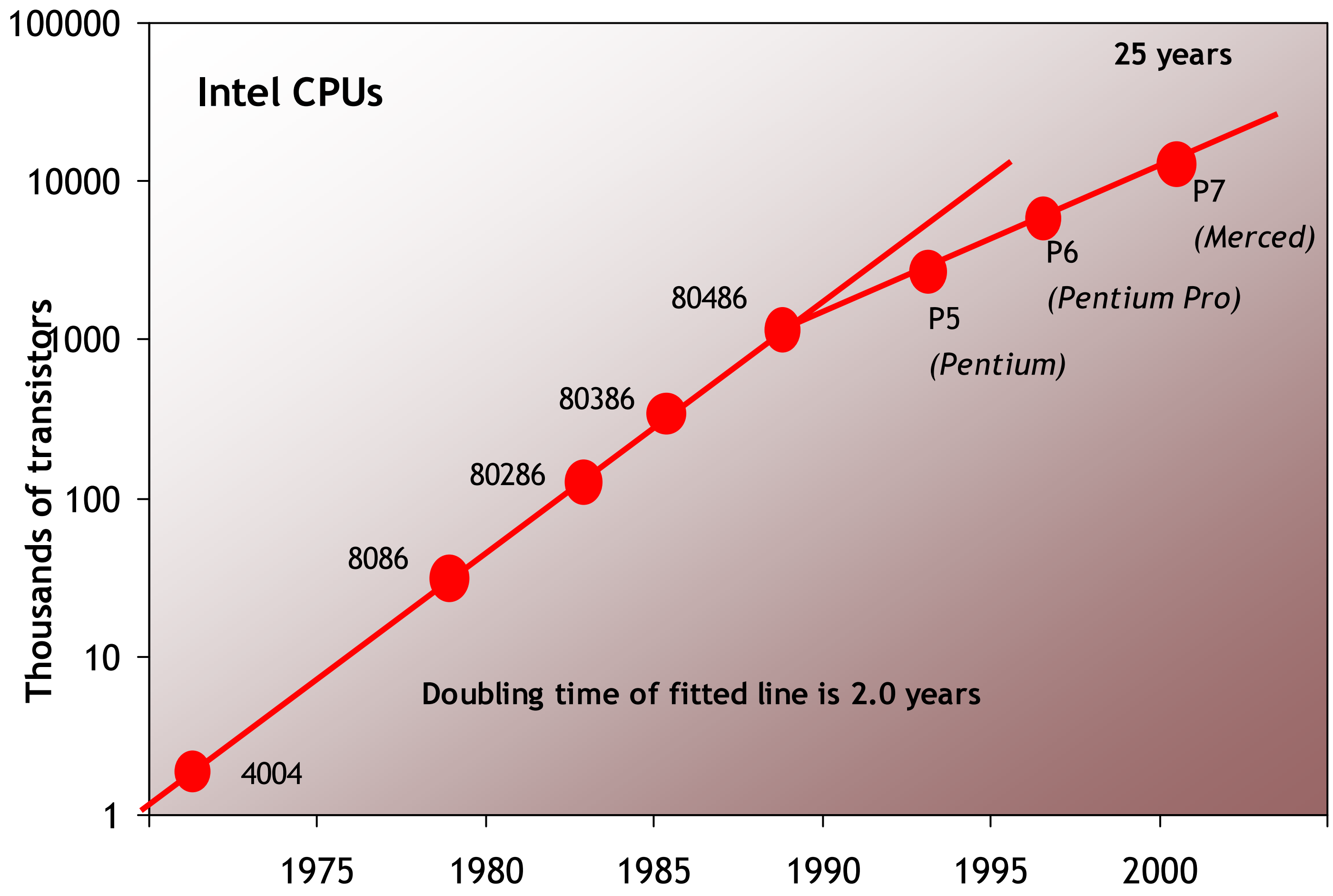
Nanomedicina


4870
4870
BNSF
Ken Whitehead

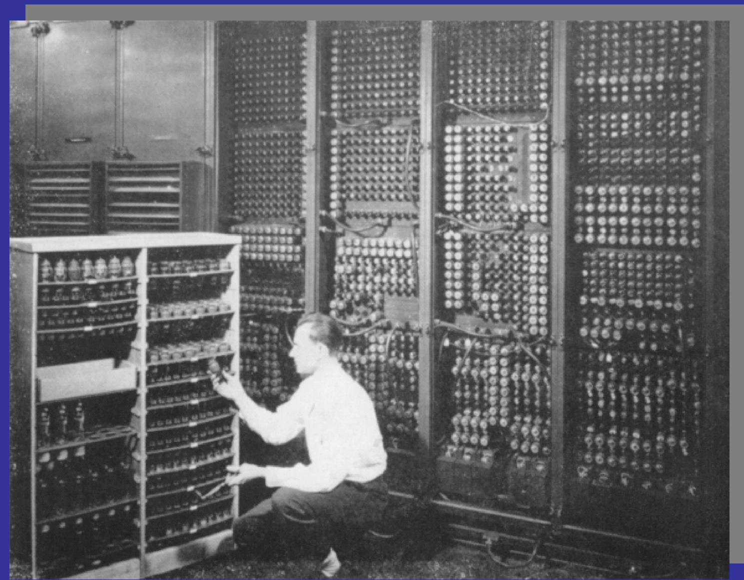

PARIS

LEY DE MOORE

"El número de transistores en un circuito integrado se dobla cada dos años"

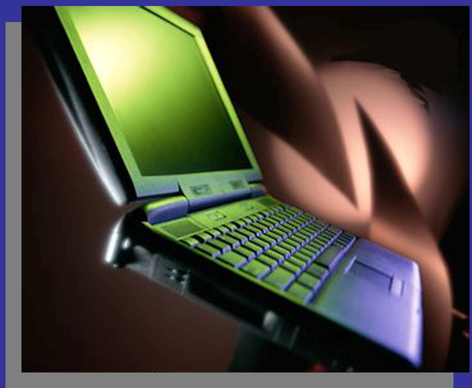


Nanoelectronics and Computing



Past

Shared computing → thousands of people sharing a mainframe computer



Present

er ona computing

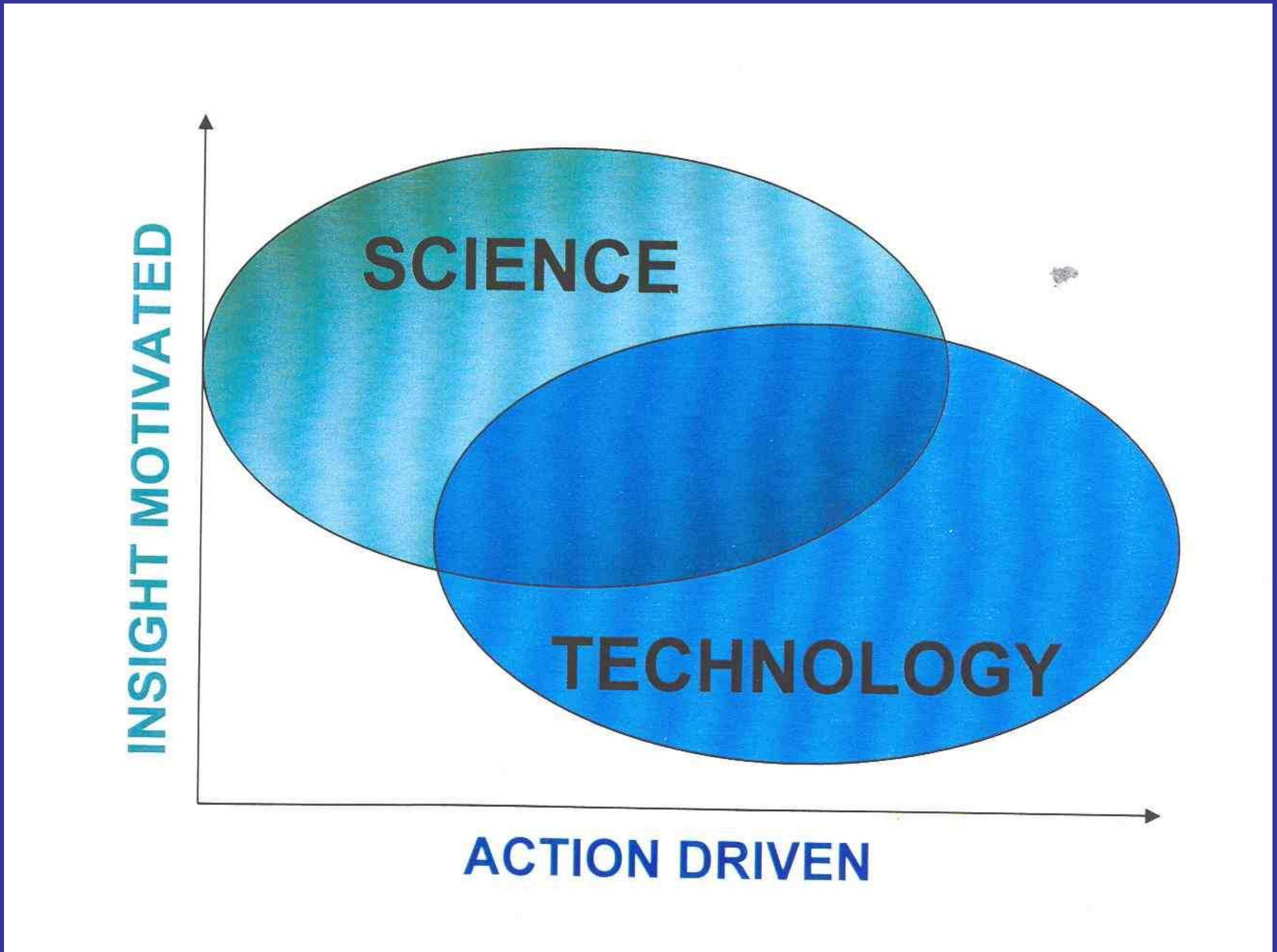
uture

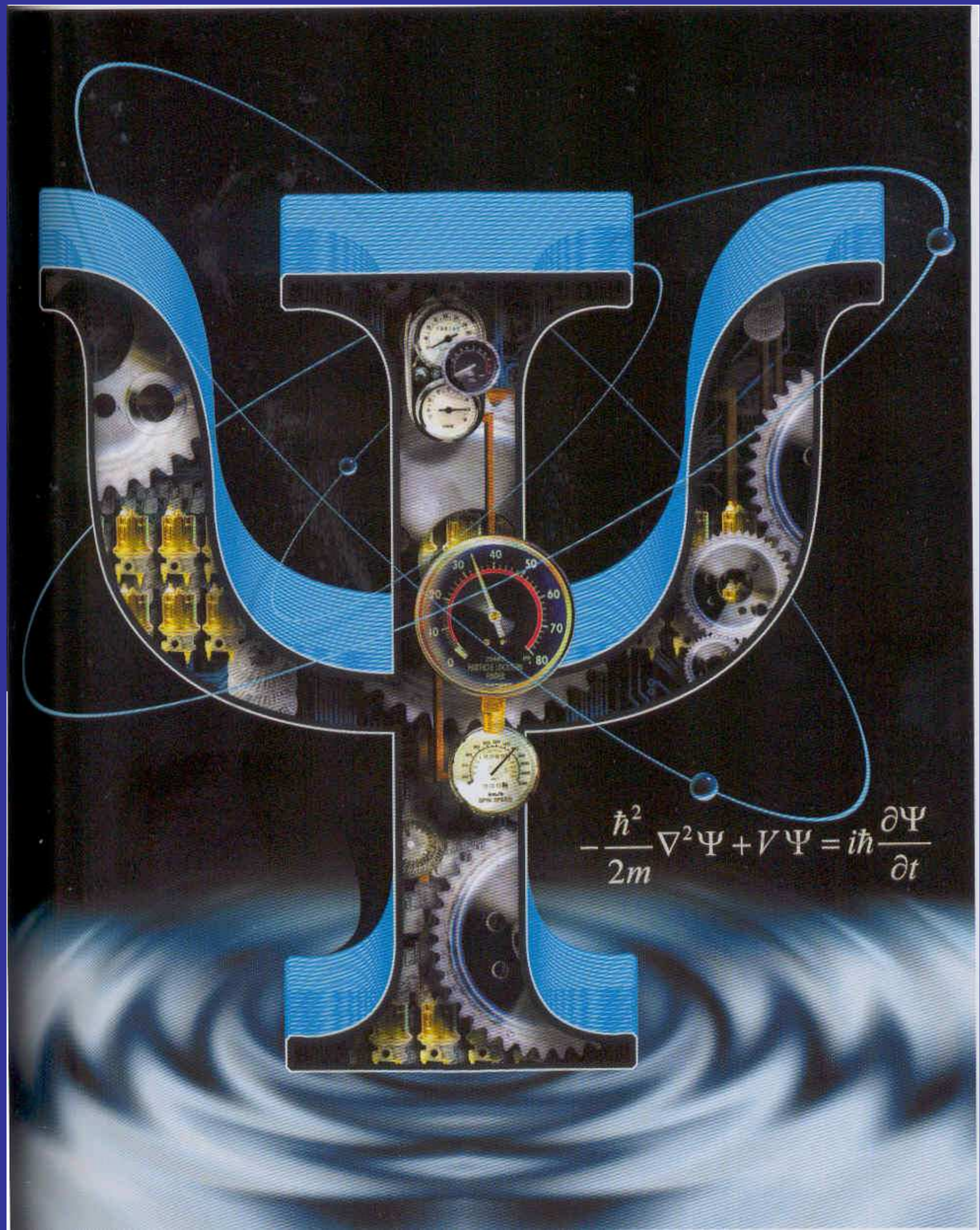
i uitou computing → thousands of computers sharing each and e er one of us computers em edded in alls chairs clothing light s itches cars characteri ed the connection of things in the orld ith computation

SCIENCE AND TECHNOLOGY ON THE NANO METER SCALE

No technology without **science**

No science without **technology**




$-\frac{\hbar^2}{2m}\nabla^2\Psi + V\Psi = i\hbar\frac{\partial\Psi}{\partial t}$

I imagine experimental physicists must often look with envy at men like Kamerlingh Onnes, who discovered a field like low temperature, which seems to be bottomless and in which one can go down and down. Such a man is then a leader and has some temporary monopoly in a scientific adventure. Percy Bridgman, in designing a way to obtain higher pressures, opened up another new field and was able to move into it and to lead us all along. The development of ever higher vacuum was a continuing development of the same kind.

We stand not only on the shoulders of a few but also at the graves of thousands.

GERALD HOLTON

“Candor and Integrity in Science”. Syntheses

I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle. This field is not quite the same as the others in that it will not tell us much of fundamental physics (in the sense of, ``What are the strange particles?'') but it is more like solid-state physics in the sense that it might tell us much of great interest about the strange phenomena that occur in complex situations. Furthermore, a point that is most important is that it would have an enormous number of technical applications.

What I want to talk about is the problem of manipulating and controlling things on a small scale.

As soon as I mention this, people tell me about miniaturization, and how far it has progressed today. They tell me about electric motors that are the size of the nail on your small finger. And there is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin. But that's nothing; that's the most primitive, halting step in the direction I intend to discuss. It is a staggeringly small world that is below. In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this direction.

Why cannot we write the entire 24 volumes of the Encyclopedia Brittanica on the head of a pin?

Let's see what would be involved. The head of a pin is a sixteenth of an inch across. If you magnify it by 25,000 diameters, the area of the head of the pin is then equal to the area of all the pages of the Encyclopaedia Brittanica. Therefore, all it is necessary to do is to reduce in size all the writing in the Encyclopaedia by 25,000 times. Is that possible? The resolving power of the eye is about 1/120 of an inch---that is roughly the diameter of one of the little dots on the fine half-tone reproductions in the Encyclopaedia. This, when you demagnify it by 25,000 times, is still 80 angstroms in diameter---32 atoms across, in an ordinary metal. In other words, one of those dots still would contain in its area 1,000 atoms. So, each dot can easily be adjusted in size as required by the photoengraving, and there is no question that there is enough room on the head of a pin to put all of the Encyclopaedia Brittanica.

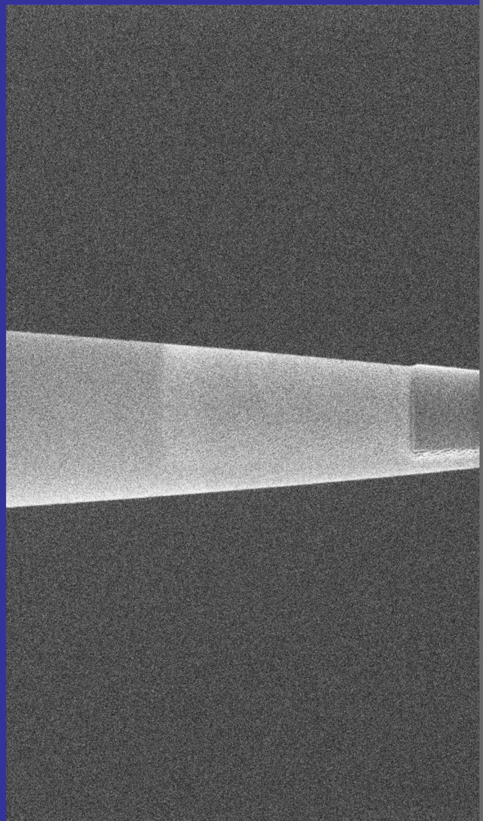
Furthermore, it can be read if it is so written. Let's imagine that it is written in raised letters of metal; that is, where the black is in the Encyclopedia, we have raised letters of metal that are actually 1/25,000 of their ordinary size. How would we read it?

If we had something written in such a way, we could read it using techniques in common use today. (They will undoubtedly find a better way when we do actually have it written, but to make my point conservatively I shall just take techniques we know today.) We would press the metal into a plastic material and make a mold of it, then peel the plastic off very carefully, evaporate silica into the plastic to get a very thin film, then shadow it by evaporating gold at an angle against the silica so that all the little letters will appear clearly, dissolve the plastic away from the silica film, and then look through it with an electron microscope!

There is no question that if the thing were reduced by 25,000 times in the form of raised letters on the pin, it would be easy for us to read it today. Furthermore; there is no question that we would find it easy to make copies of the master; we would just need to press the same metal plate again into plastic and we would have another copy.

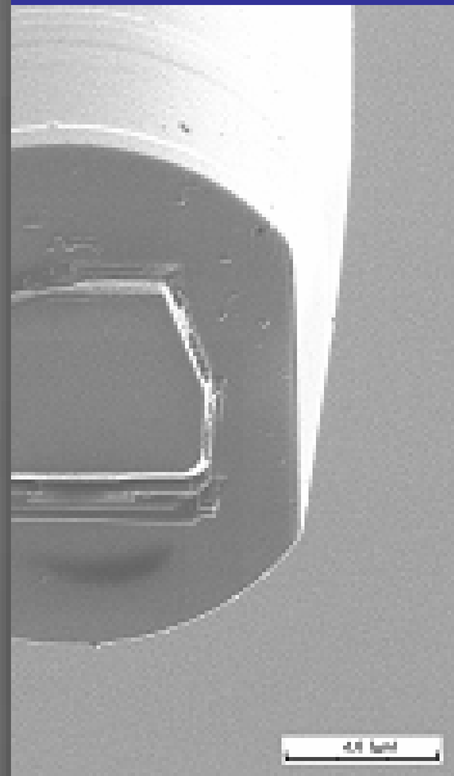
The next question is: How do we *write* it? We have no standard technique to do this now. But let me argue that it is not as difficult as it first appears to be. We can reverse the lenses of the electron microscope in order to demagnify as well as magnify. A source of ions, sent through the microscope lenses in reverse, could be focused to a very small spot. We could write with that spot like we write in a TV cathode ray oscilloscope, by going across in lines, and having an adjustment which determines the amount of material which is going to be deposited as we scan in lines.

Nanotechnique



Inner diameter ~100nm

World smallest
wine glass!



Inner diameter 8.6mm

Thickness 250nm Si

Kaito et al., SII

Cell surgery in nm range soon!

A simpler way might be this (though I am not sure it would work): We take light and, through an optical microscope running backwards, we focus it onto a very small photoelectric screen. Then electrons come away from the screen where the light is shining. These electrons are focused down in size by the electron microscope lenses to impinge directly upon the surface of the metal. Will such a beam etch away the metal if it is run long enough? I don't know. If it doesn't work for a metal surface, it must be possible to find some surface with which to coat the original pin so that, where the electrons bombard, a change is made which we could recognize later.

All of the information which all of mankind has every recorded in books can be carried around in a pamphlet in your hand---and not written in code, but a simple reproduction of the original pictures, engravings, and everything else on a small scale without loss of resolution.

When the University of Brazil, for example, finds that their library is burned, we can send them a copy of every book in our library by striking off a copy from the master plate in a few hours and mailing it in an envelope no bigger or heavier than any other ordinary air mail letter.

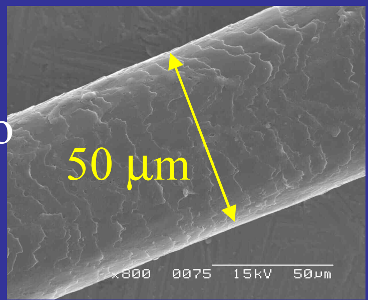
I have estimated how many letters there are in the Encyclopaedia, and I have assumed that each of my 24 million books is as big as an Encyclopaedia volume, and have calculated, then, how many bits of information there are (10^15). For each bit I allow 100 atoms. And it turns out that all of the information that man has carefully accumulated in all the books in the world can be written in this form in a cube of material one two-hundredth of an inch wide---which is the barest piece of dust that can be made out by the human eye. So there is *plenty* of room at the bottom! Don't tell me about microfilm!

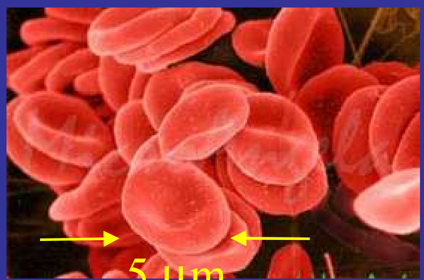
This fact---that enormous amounts of information can be carried in an exceedingly small space---is, of course, well known to the biologists, and resolves the mystery which existed before we understood all this clearly, of how it could be that, in the tiniest cell, all of the information for the organization of a complex creature such as ourselves can be stored. All this information---whether we have brown eyes, or whether we think at all, or that in the embryo the jawbone should first develop with a little hole in the side so that later a nerve can grow through it---all this information is contained in a very tiny fraction of the cell in the form of long-chain DNA molecules in which approximately 50 atoms are used for one bit of information about the cell.

El nanomundo

25 mm

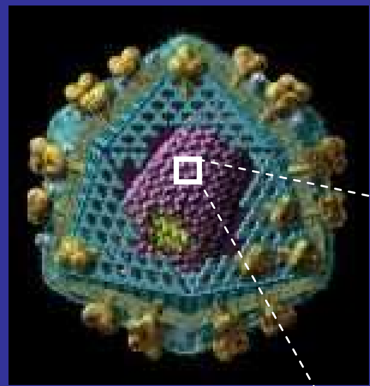
Cabello humano





Glóbulos rojos

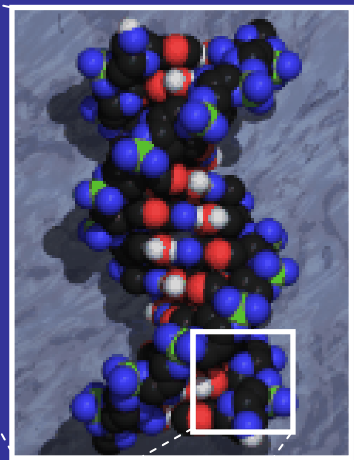
Virus SIDA



100 nm

AD

nm



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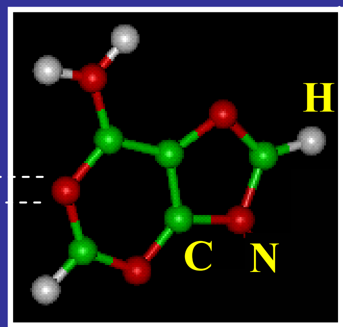
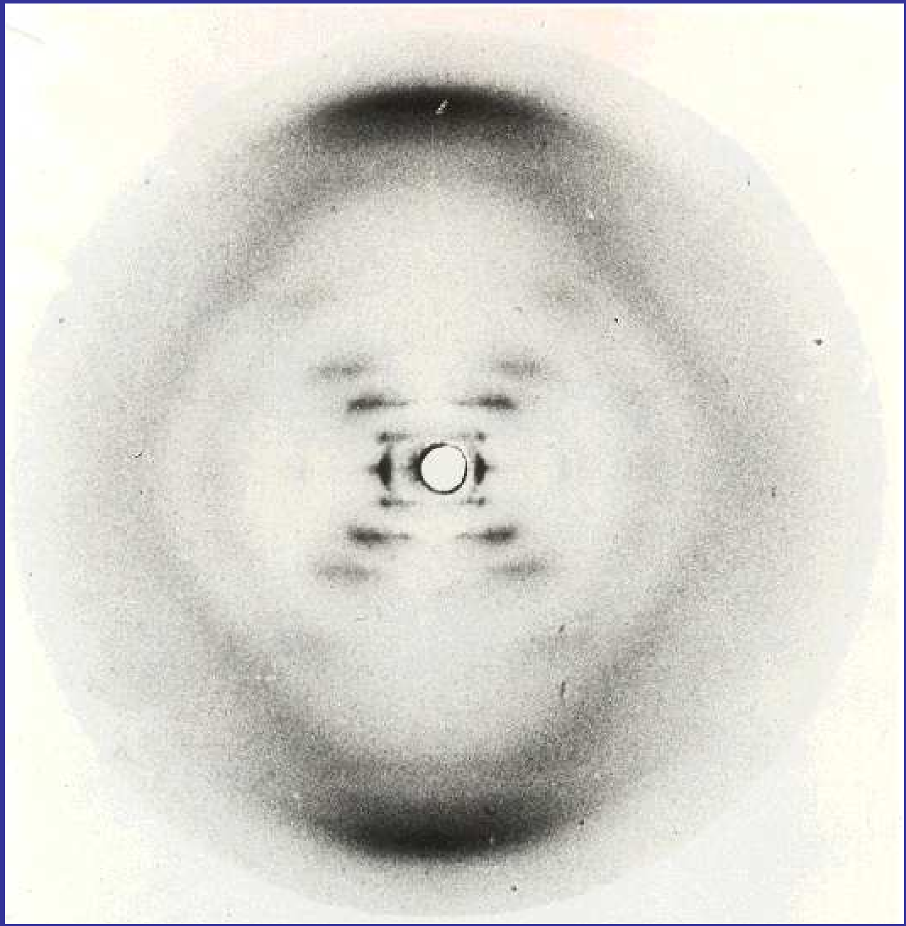
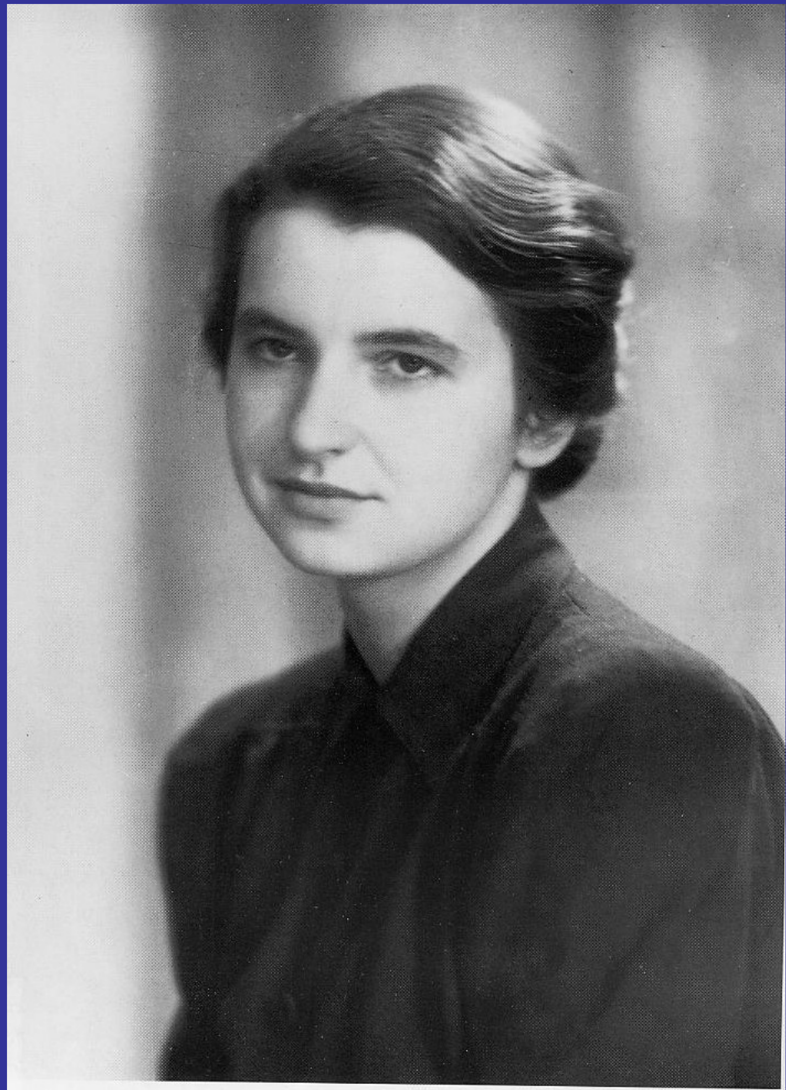


James Watson Francis Crick

Rosalind Franklin

ra ra on b a ber





Too deep for tears: Rosalind in a pensive mood.

« Her photographs are among the most beautiful X-ray photographs of any substance ever taken. »

Rosalind Franklin, the Dark Lady of DNA **H C**

TPN 3,57%

2005 4,4%

V Congreso de la Sociedad Solvay, Bruselas, 1927

3,4%

Mujeres Premio Nobel en Física

03

*Por sus trabajos en fenómenos de radiacción (¼, **2 hijos**)*
1906 Sorbona

3

Estructura de capas del núcleo
*(¼, **2 hijos**) 1960 UC-San Diego*

No fueron premiadas, entre otras…..

Chien-Shiung Wu, Física 1957, Lee y Yang *violación de la paridad (**1 hijo**)*

Lise Meitner, Química 1944, Hahn *fisión nuclear*

Rosalind Franklin, Medicina 1965, Crick, Watson, Wilkins
s ru ur AD

Jocelyn Bell Burnell, Física 1974, Hewish
s u ri i s
*s r s **1 hijo***

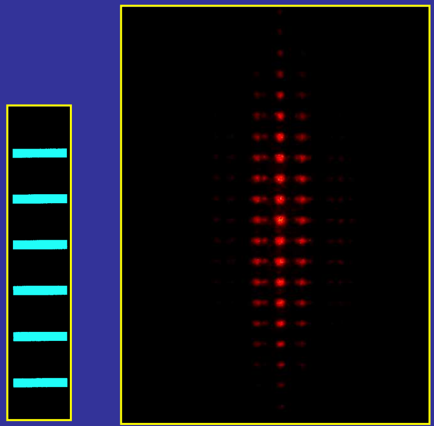
Corporaciones científicas

- Academia dei Lincei (Roma 1630)
- Academia de Cimento (Florencia 1657)
- Royal Society (Londres 1662) 1945
- Academie des Sciences (París 1666) 1979
- Akademie der Wissenschaften (Berlín 1700) 1964
- Real Academia de Ciencias (Madrid 1847) 1988
- Royal Institution (Londres 1799) Conde Rumford

R. Boyle

THE STRUCTURE OF B-DNA

1



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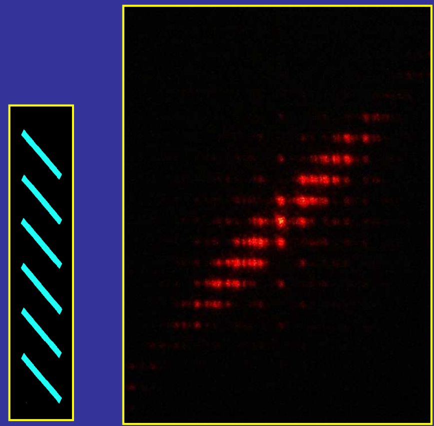

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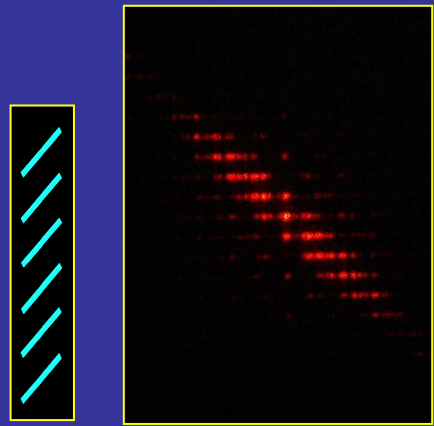
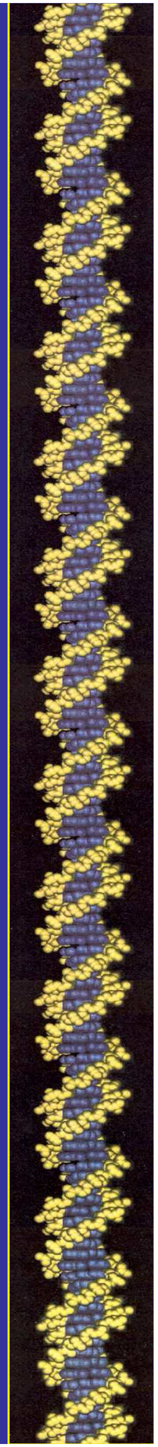


Courtesy of A. Lucas



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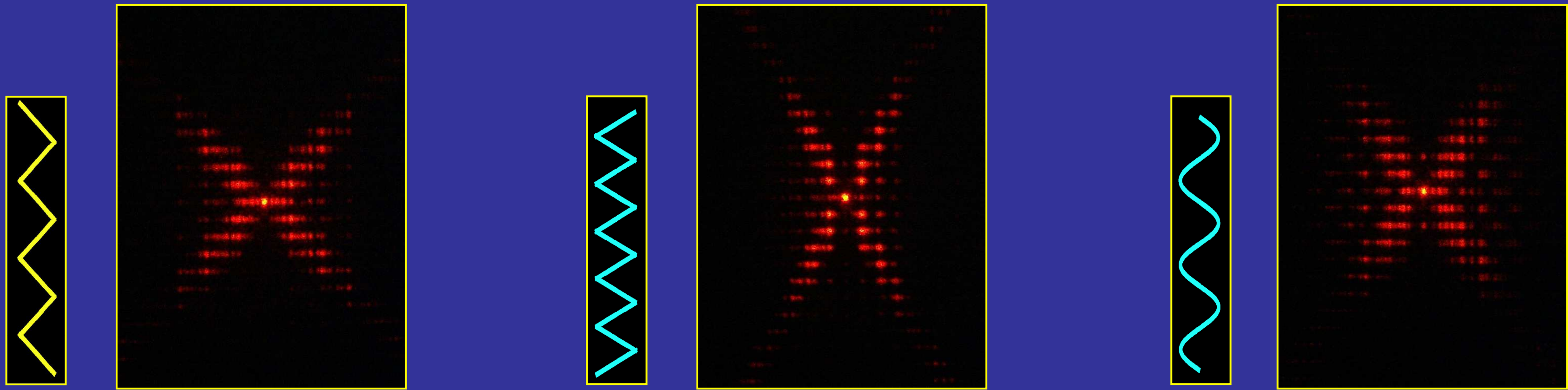

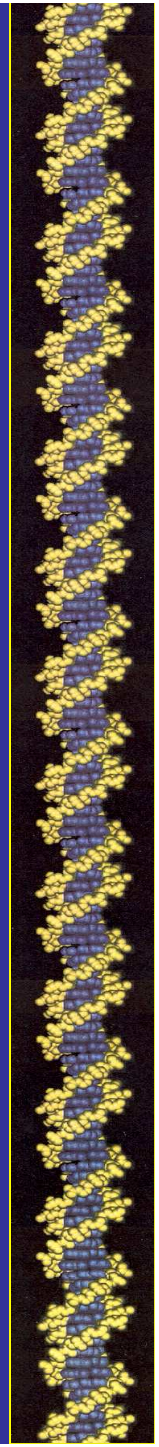

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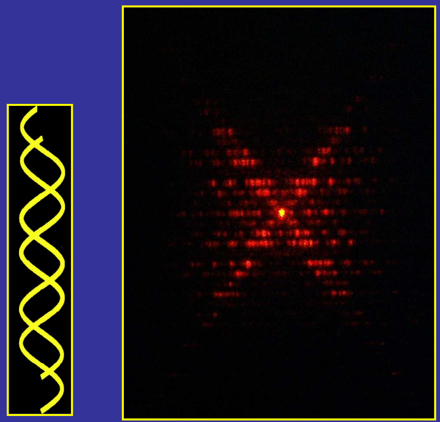
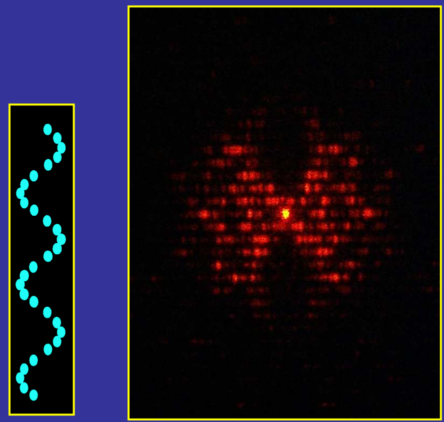
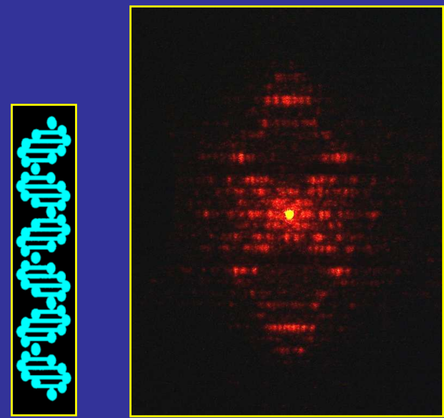
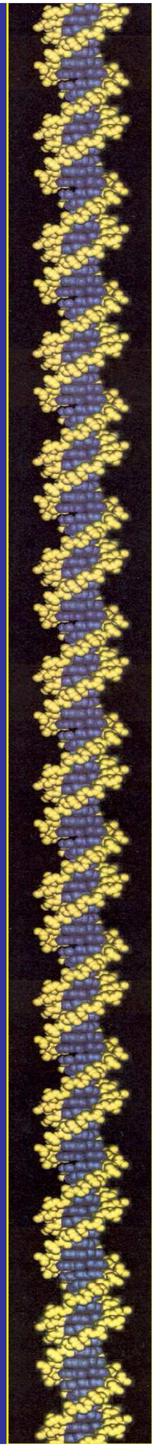


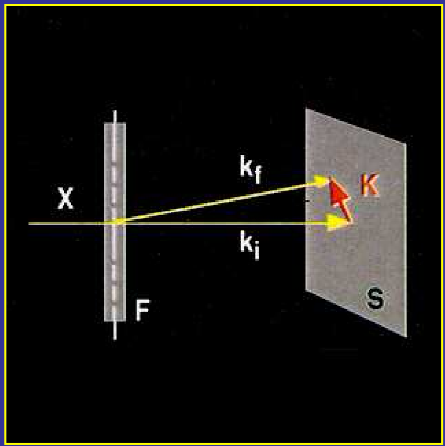






THE STRUCTURE OF B-DNA

1



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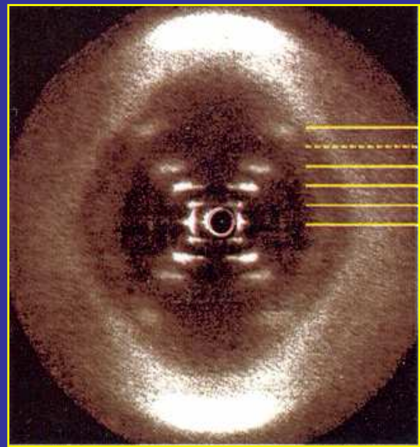

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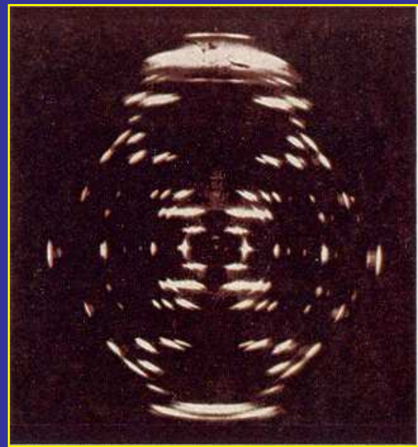


A. Lucas

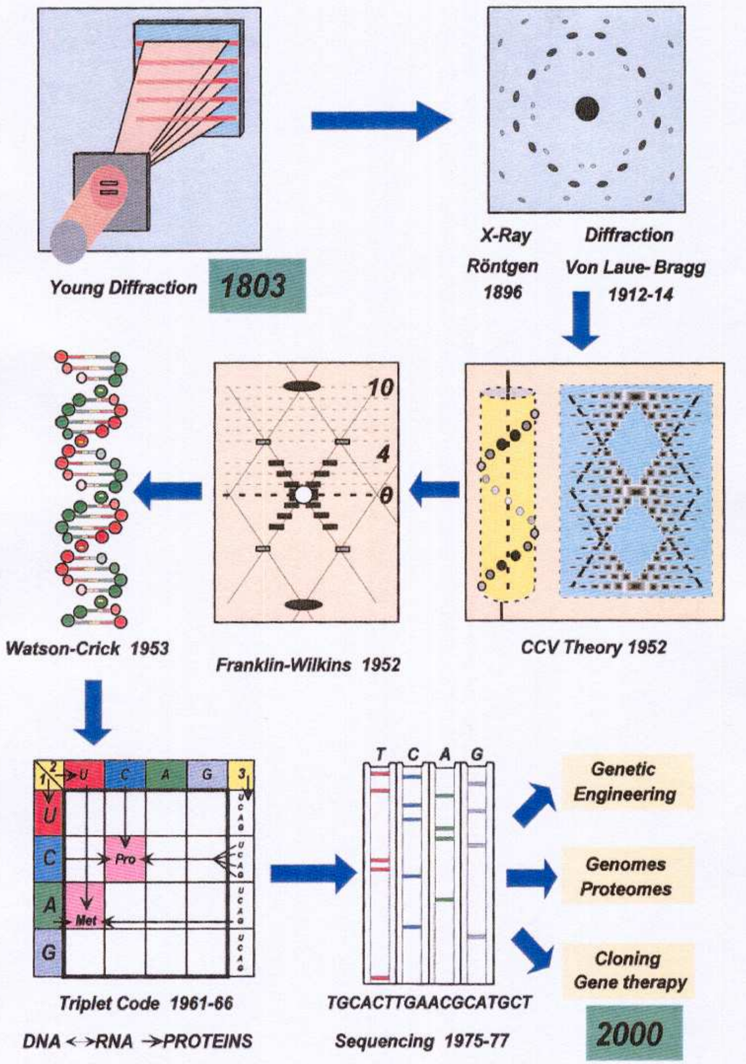
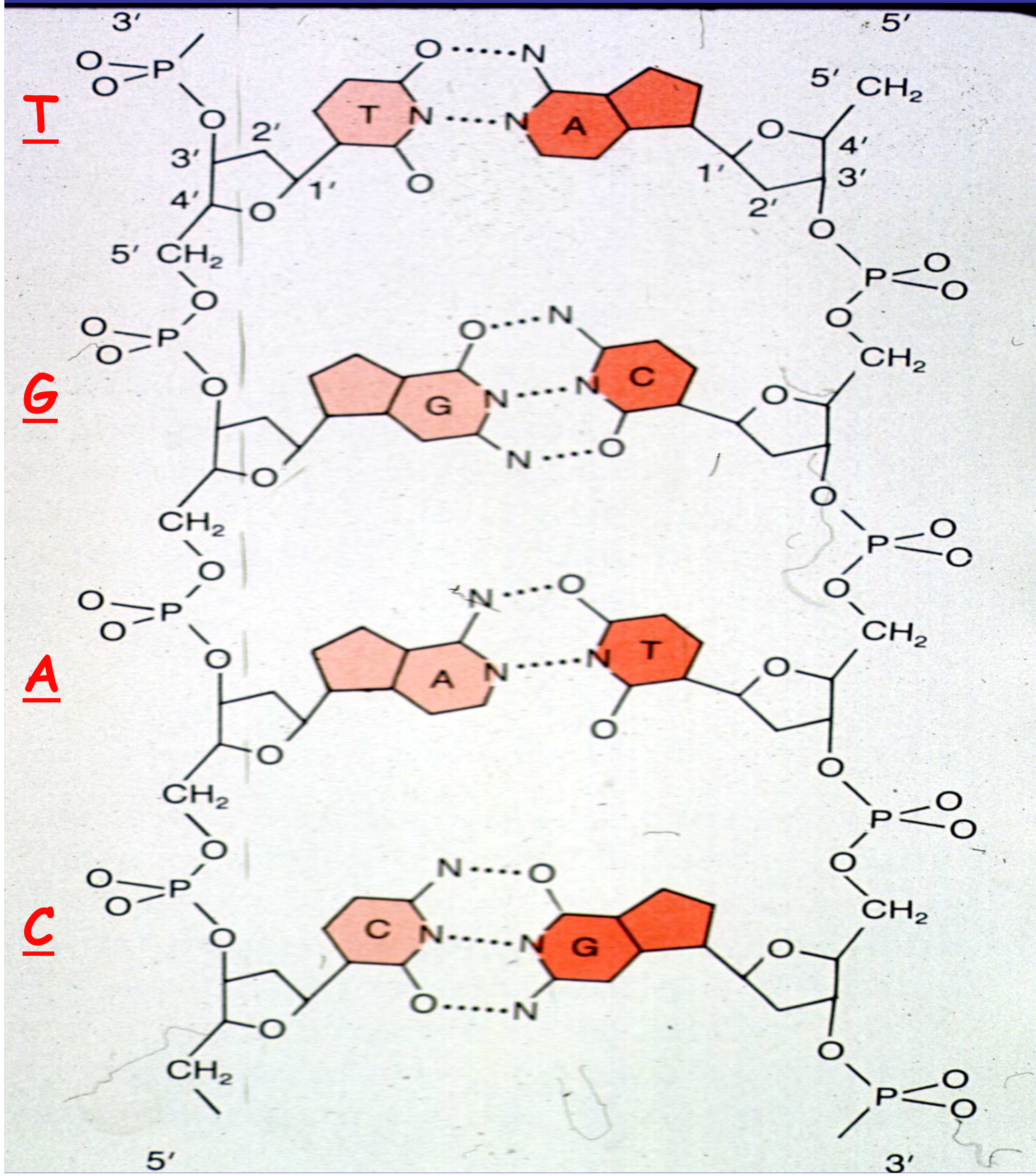
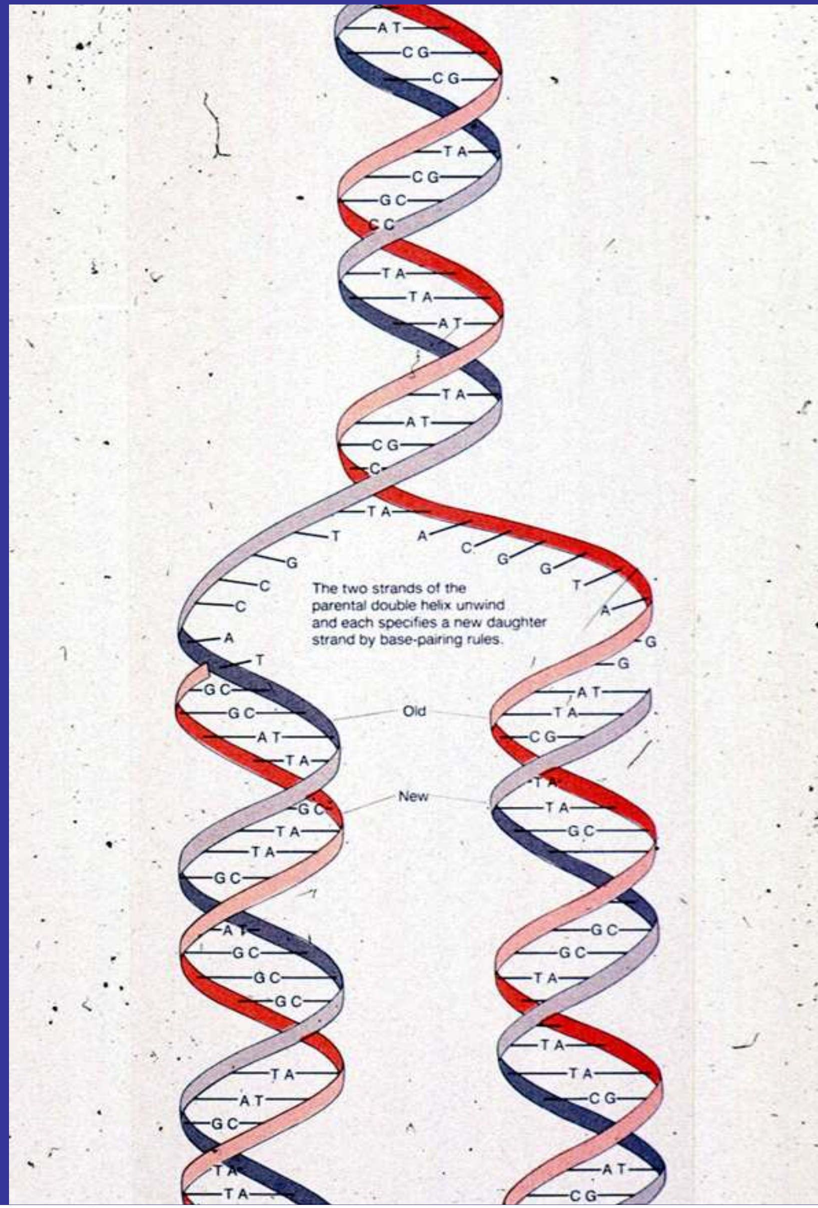
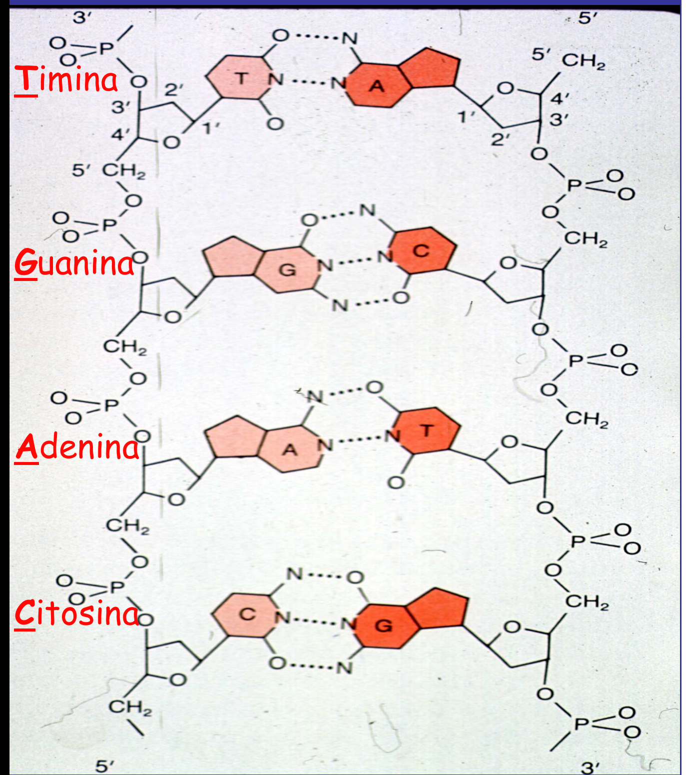


FIGURE 1. Guided tour through the history of sciences beginning with the discovery of the wave nature of light (1803) and ending with modern genetic engineering (2000). The path indicated by the arrows is described in Section 2. The central picture is a schematic representation of the real X-ray diagram in Fig. 2(a).

La estructura del A e lica la naturale a y la re licaci n del material en tico






Timina
Guanina
Adenina
Citosina
3′
5′
5′
3′

What are the most central and fundamental problems of biology today? They are questions like: What is the sequence of bases in the DNA? What happens when you have a mutation? How is the base order in the DNA connected to the order of amino acids in the protein? What is the structure of the RNA; is it single-chain or double-chain, and how is it related in its order of bases to the DNA? What is the organization of the microsomes? How are proteins synthesized? Where does the RNA go? How does it sit? Where do the proteins sit? Where do the amino acids go in? In photosynthesis, where is the chlorophyll; how is it arranged; where are the carotenoids involved in this thing? What is the system of the conversion of light into chemical energy?

It is very easy to answer many of these fundamental biological questions; you just *look at the thing!* You will see the order of bases in the chain; you will see the structure of the microsome. Unfortunately, the present microscope sees at a scale which is just a bit too crude. Make the microscope one hundred times more powerful, and many problems of biology would be made very much easier. I exaggerate, of course, but the biologists would surely be very thankful to you---and they would prefer that to the criticism that they should use more mathematics.

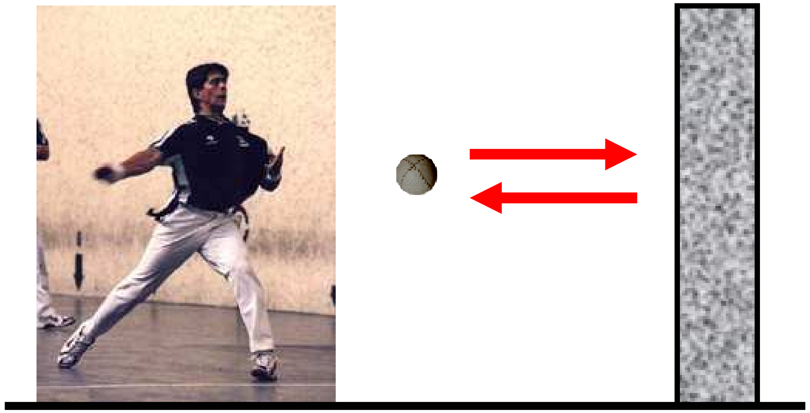
A friend of mine (Albert R. Hibbs) suggests a very interesting possibility for relatively small machines. He says that, although it is a very wild idea, it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and ``looks'' around. (Of course the information has to be fed out.) It finds out which valve is the faulty one and takes a little knife and slices it out. Other small machines might be permanently incorporated in the body to assist some inadequately-functioning organ.

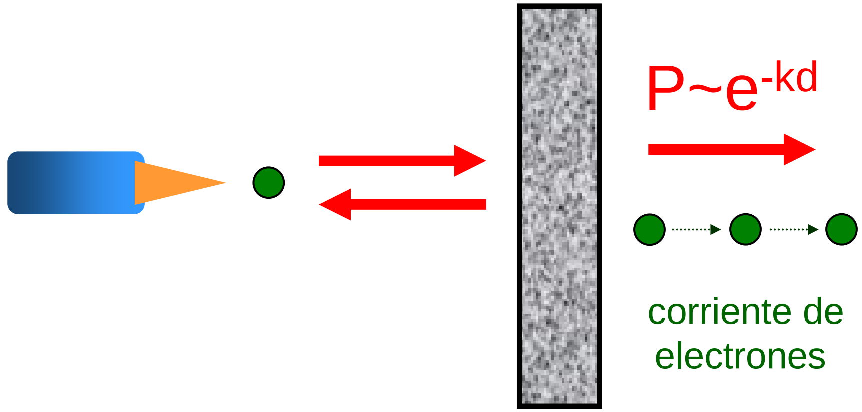
Rearranging the atoms

The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom. It is not an attempt to violate any laws; it is something, in principle, that can be done; but in practice, it has not been done because we are too big.

But it is interesting that it would be, in principle, possible (I think) for a physicist to synthesize any chemical substance that the chemist writes down. Give the orders and the physicist synthesizes it. How? Put the atoms down where the chemist says, and so you make the substance. The problems of chemistry and biology can be greatly helped if our ability to see what we are doing, and to do things on an atomic level, is ultimately developed---a development which I think cannot be avoided.

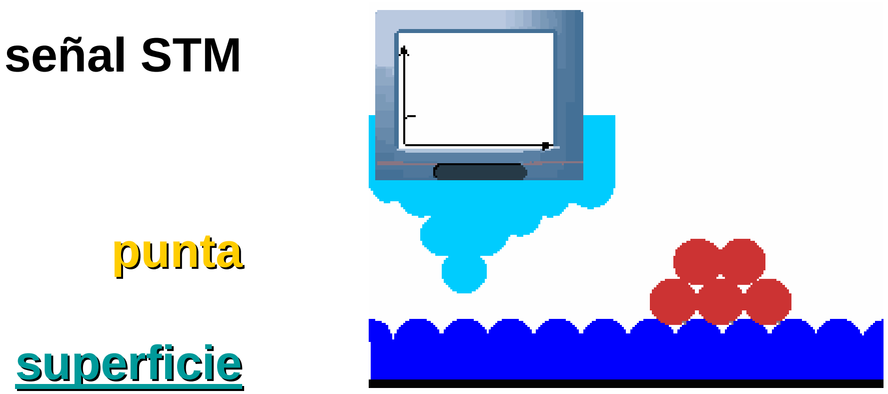
efectos cuánticos: corriente túnel





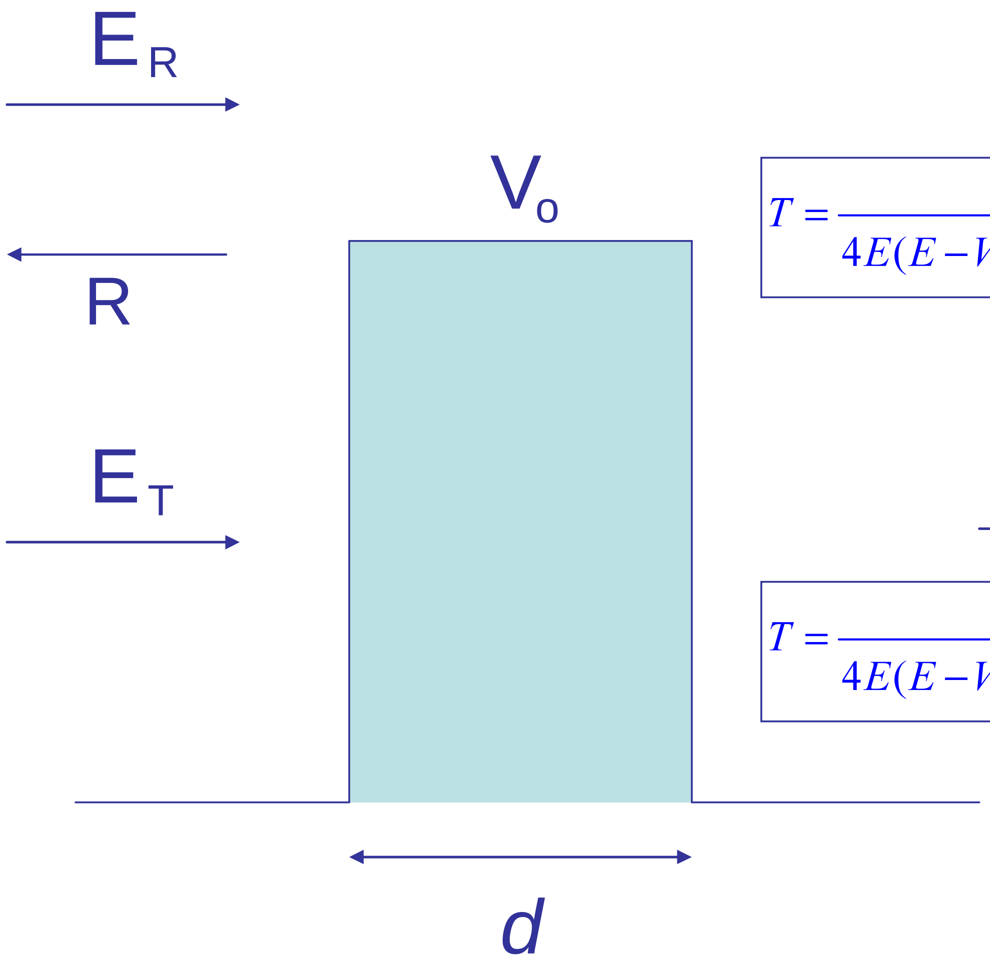
escala macroscópica:
la pelota siempre rebota

escala microscópica:
¡las partículas cuánticas pueden pasar!



manteniendo una corriente de electrones constante desde la punta hacia la superficie, podemos obtener el perfil de ésta con resolución atómica

Tunnel effect



T R

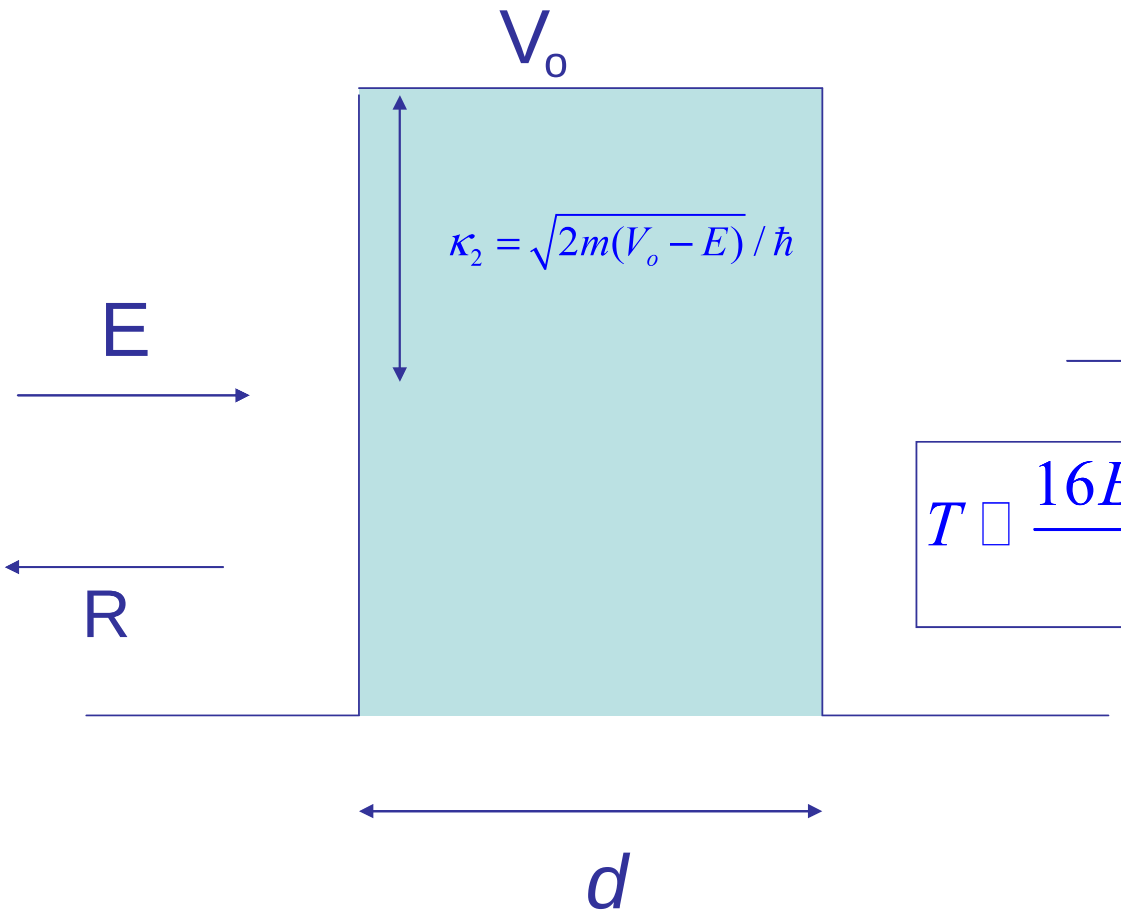
$$T = \frac{4E(E-V_o)}{4E(E-V_o)+V_o^2\sin^2\left[\sqrt{2m(E-V_o)}d/\hbar\right]}$$

T T

$$T = \frac{4E(E-V_o)}{4E(E-V_o)+V_o^2\sin^2\left[\sqrt{2m(E-V_o)}d/\hbar\right]}$$

$$T \approx \frac{16E(V_o-E)}{V_o^2}e^{-2\kappa_2 d}$$

Tunnel effect

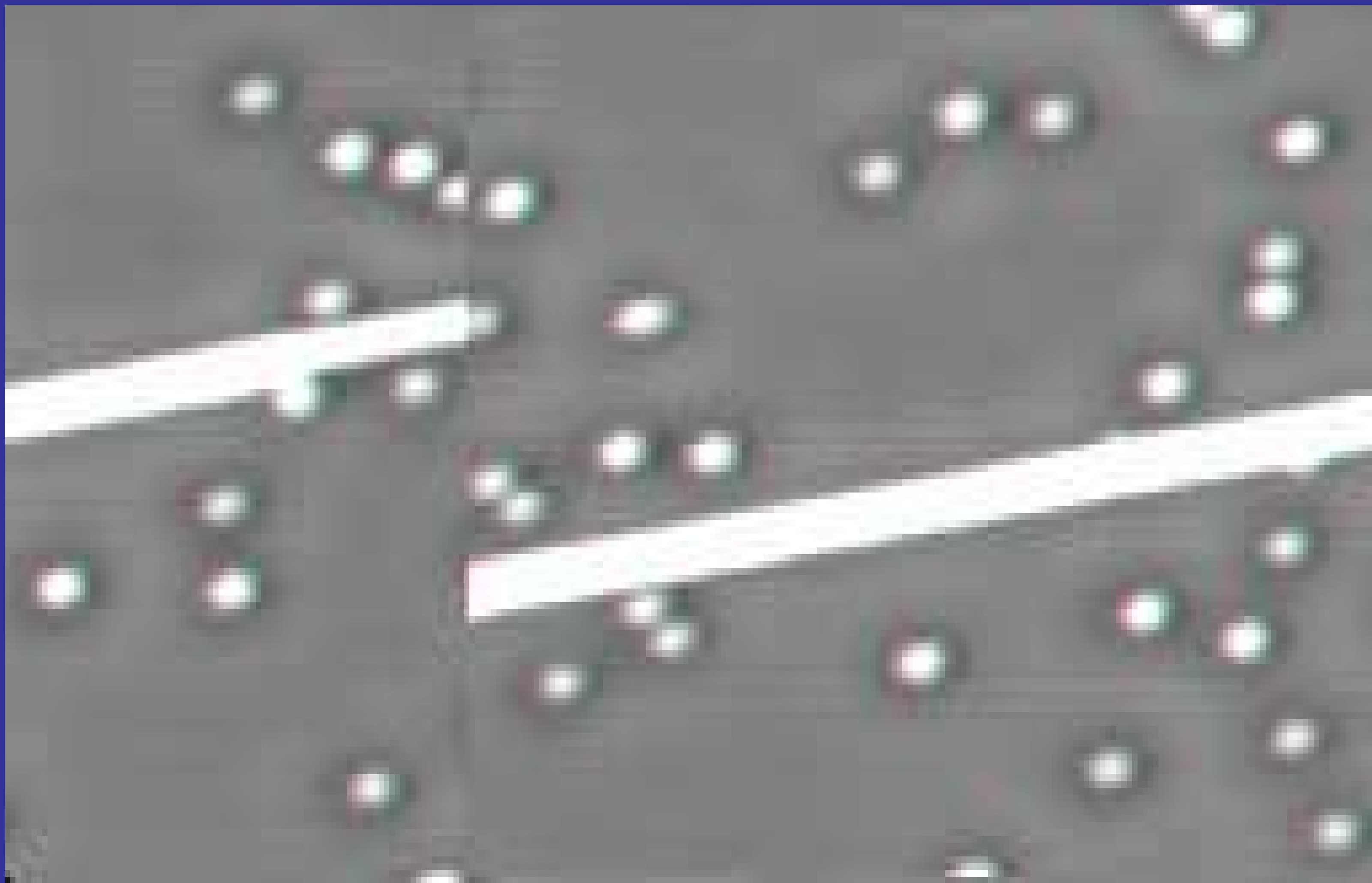


$$\kappa_2 = \sqrt{2m(V_o - E)} / \hbar$$

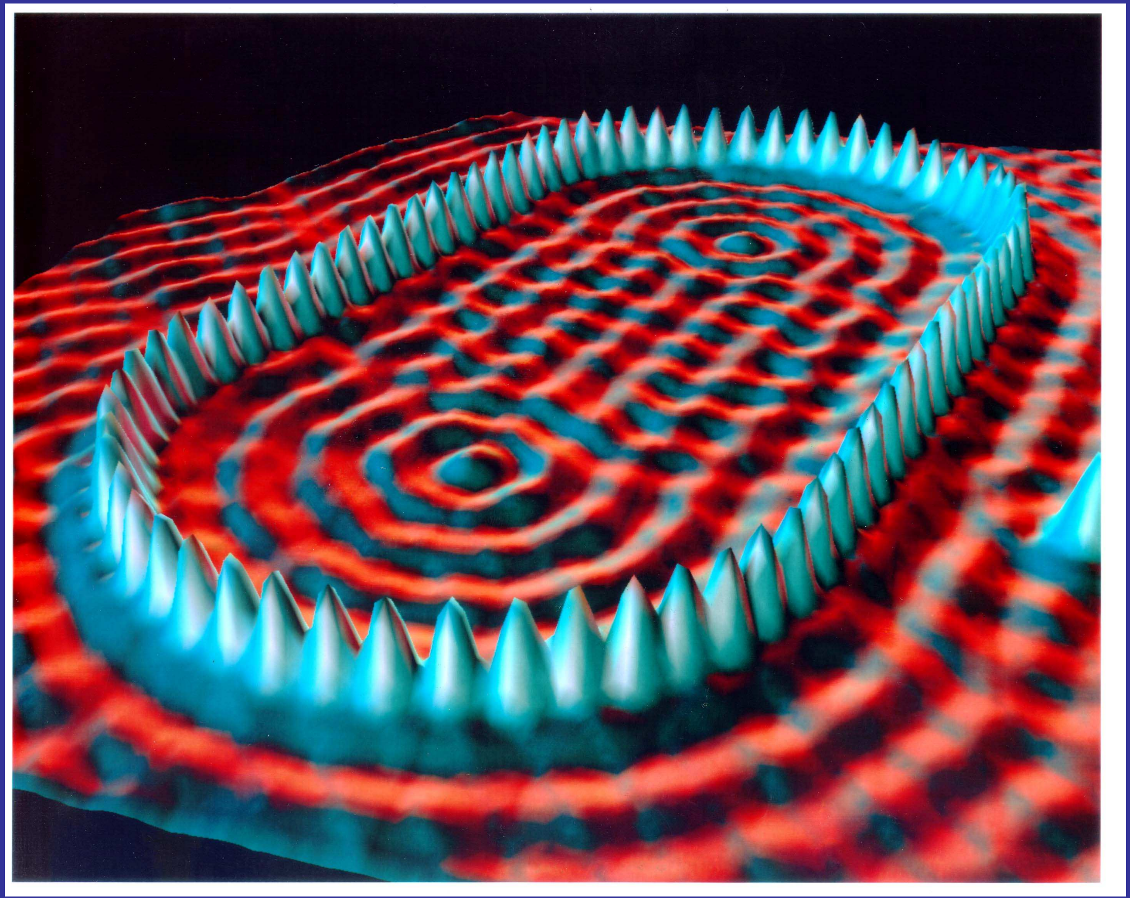
$$T \approx \frac{16E(V_o - E)}{V_o^2} e^{-2\kappa_2 d}$$

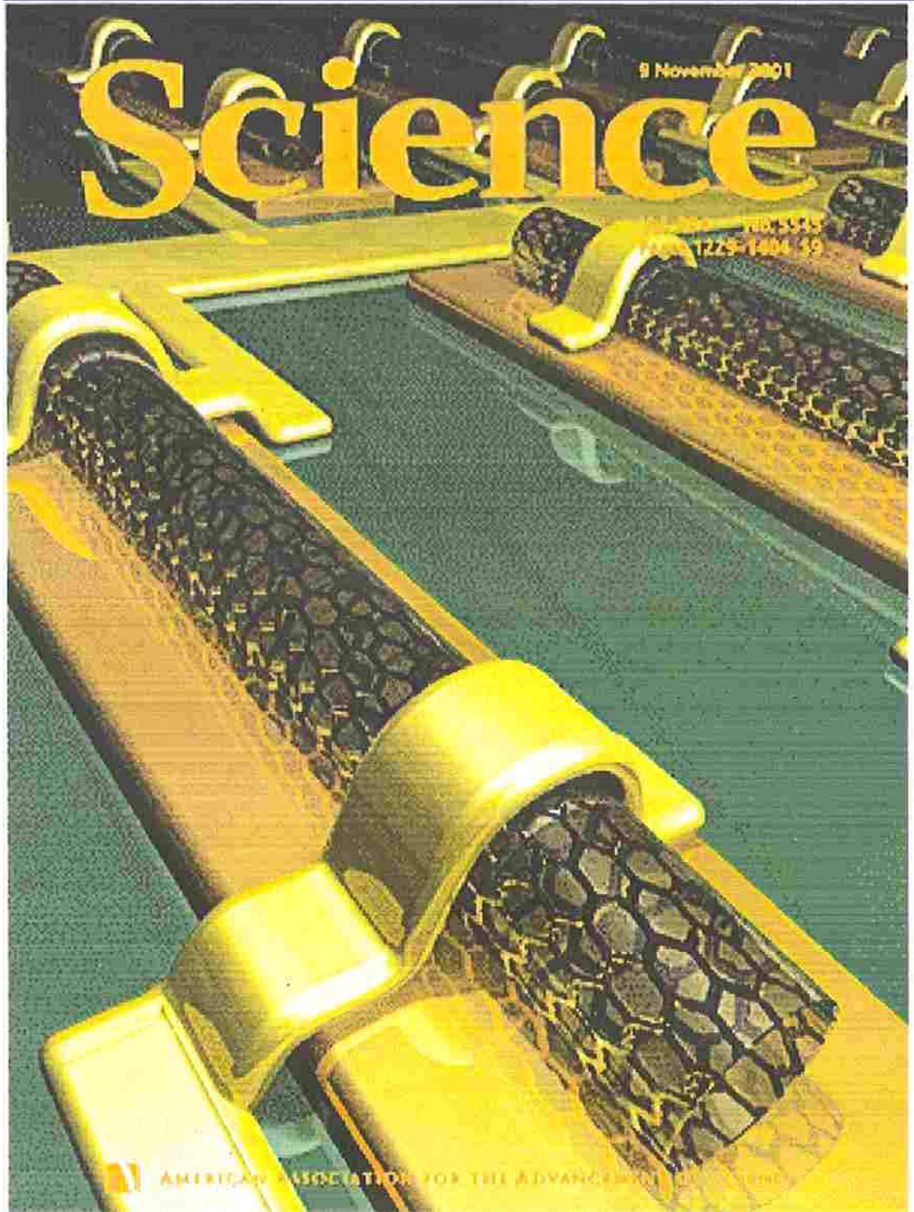
PELÍCULA TÚNEL

PELÍCULA DIPC



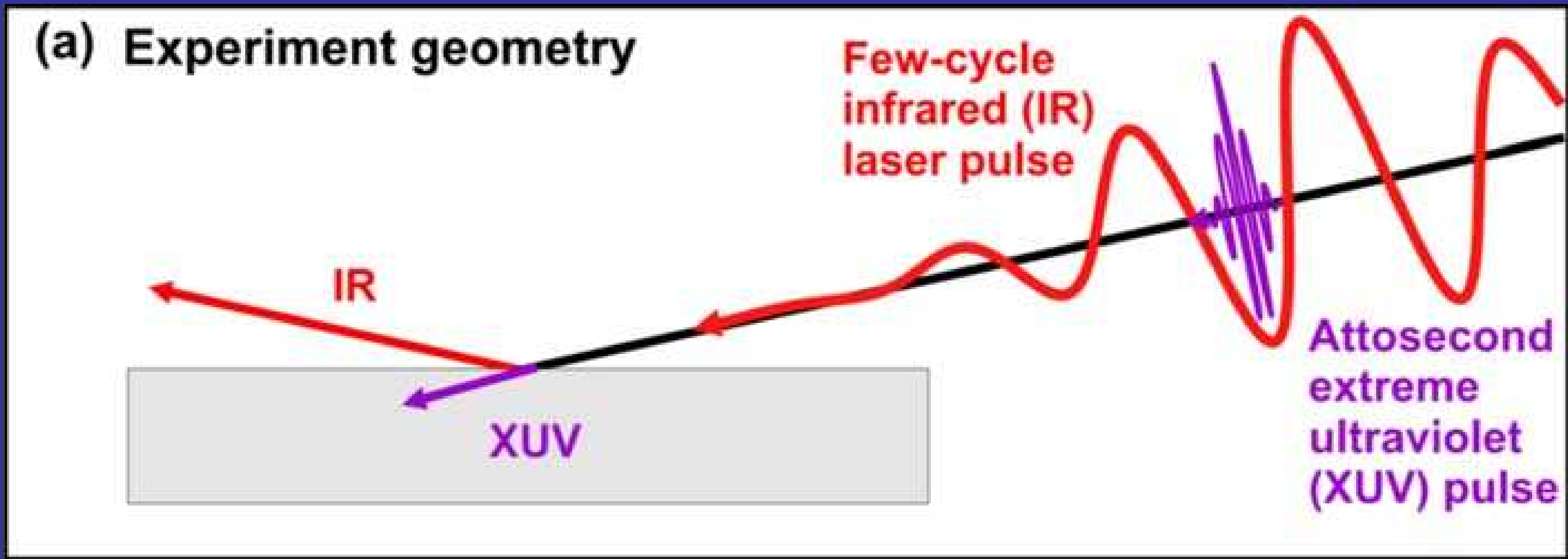
Stadium corral

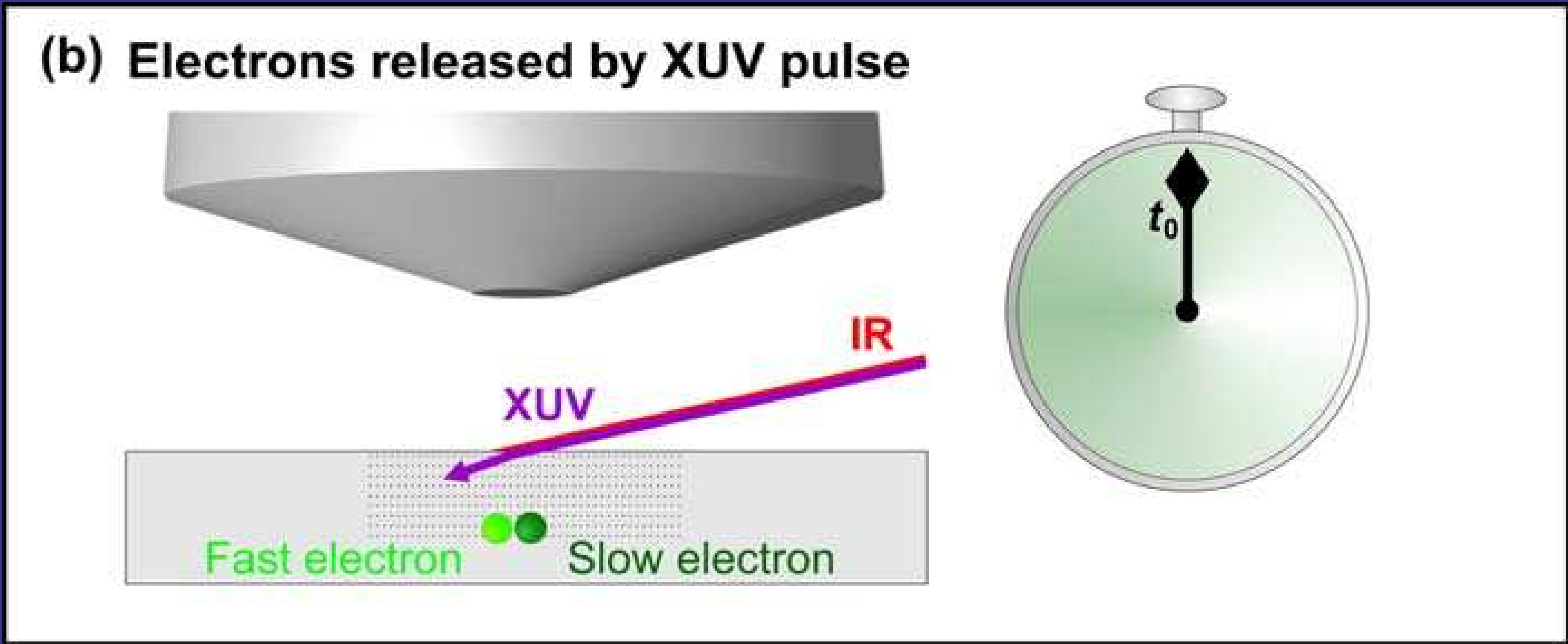


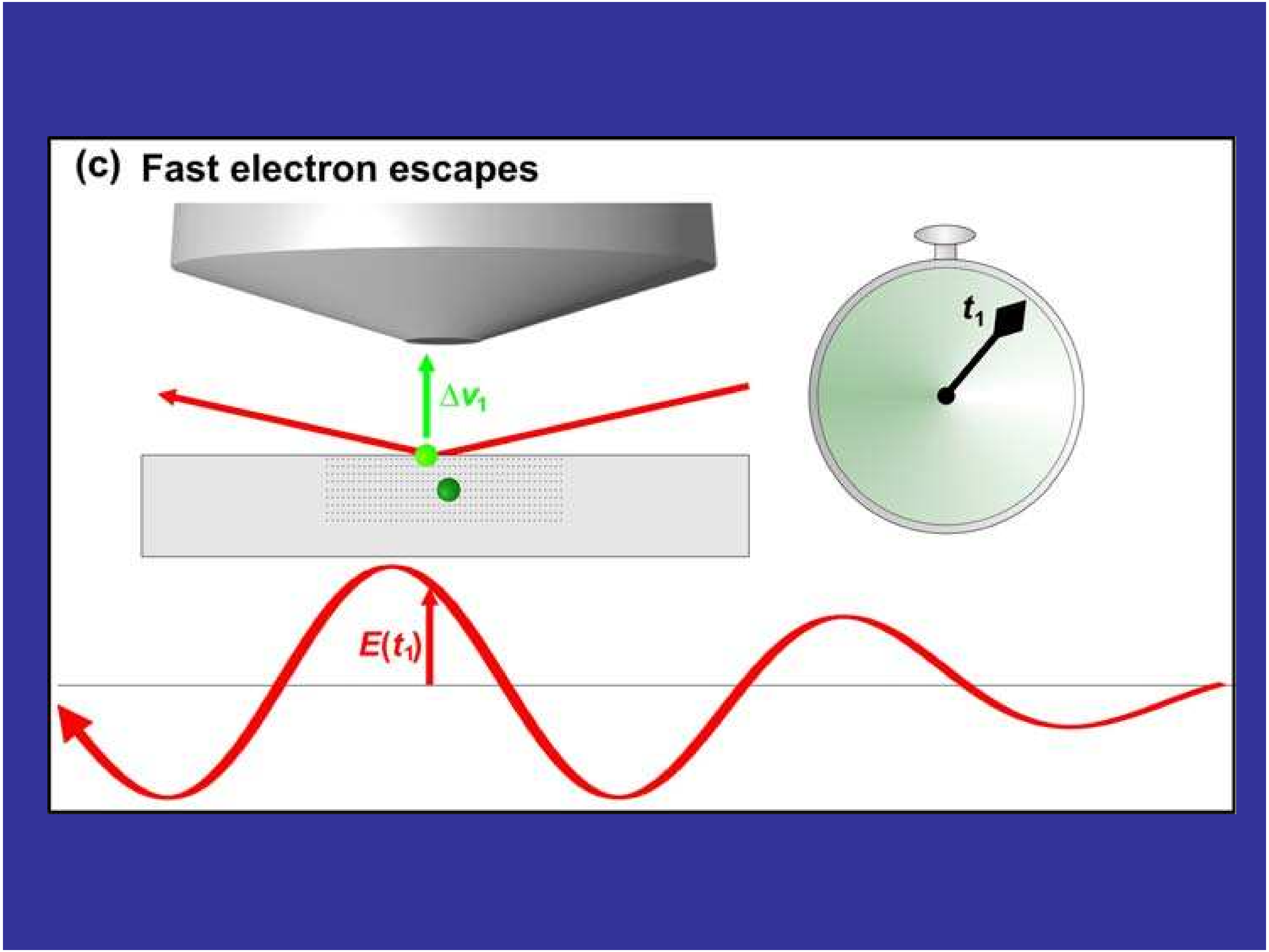

Science

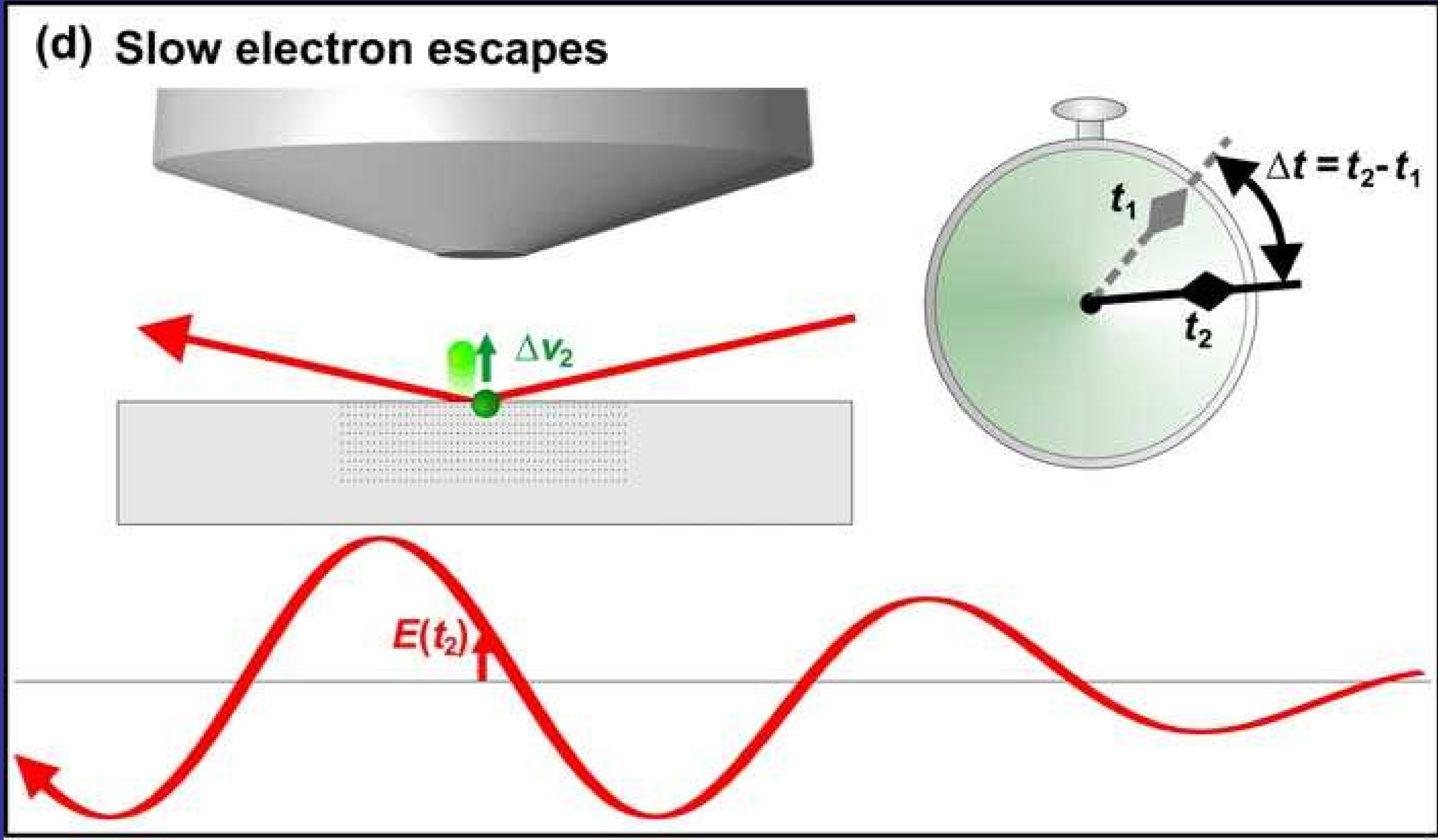

21 December 2001
Science
Vol. 294 No. 5551
Pages 2417-2616 $9
Breakthrough
of the Year
Nanocircuits
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE


25 October 2007 | www.nature.com/nature | $10
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE
nature
SEE HOW THEY RUN
Attosecond electron transport in real time
~110 attoseconds
AFGHANISTAN
Natural resources as a lifeline
CLIMATE POLITICS
A radical alternative
AUTUMN BOOKS
Why music matters and how science is done
NATUREJOBS
Postdocs to spare


(a) Experiment geometry
Few-cycle infrared (IR) laser pulse
Attosecond extreme ultraviolet (XUV) pulse
IR
XUV


(b) Electrons released by XUV pulse
IR
XUV
Fast electron
Slow electron
t0

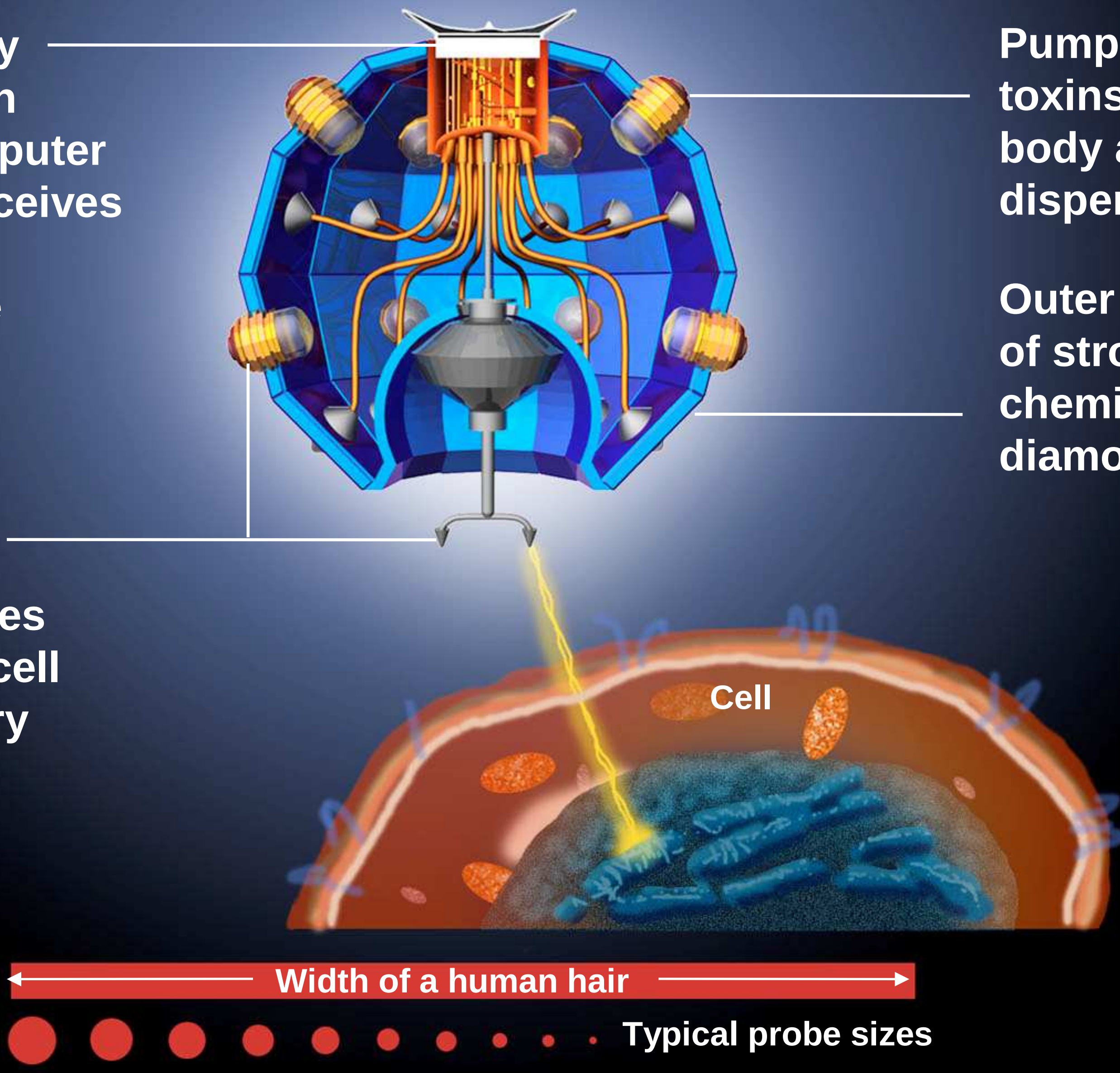

(c) Fast electron escapes
Δv_1
t_1
$E(t_1)$


(d) Slow electron escapes
Δv₂
Δt = t₂- t₁
t₁
t₂
E(t₂)

Anatomy of a Nanoprobe

Acoustic relay attached to an onboard computer sends and receives ultrasound to communicate with medical team

Sensors and manipulators detect illnesses and perform cell by cell surgery



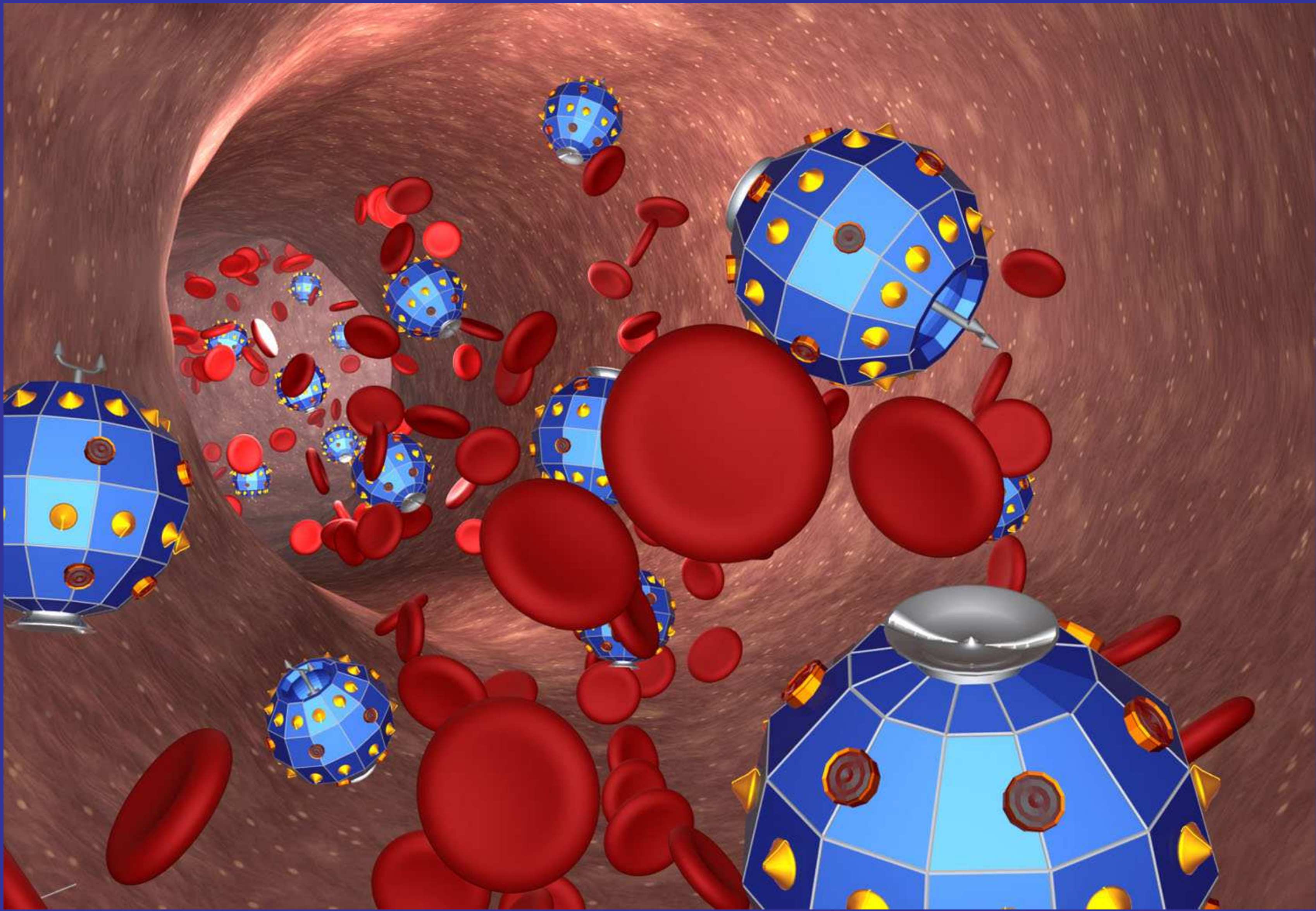
Pumps remove toxins from the body and disperse drugs

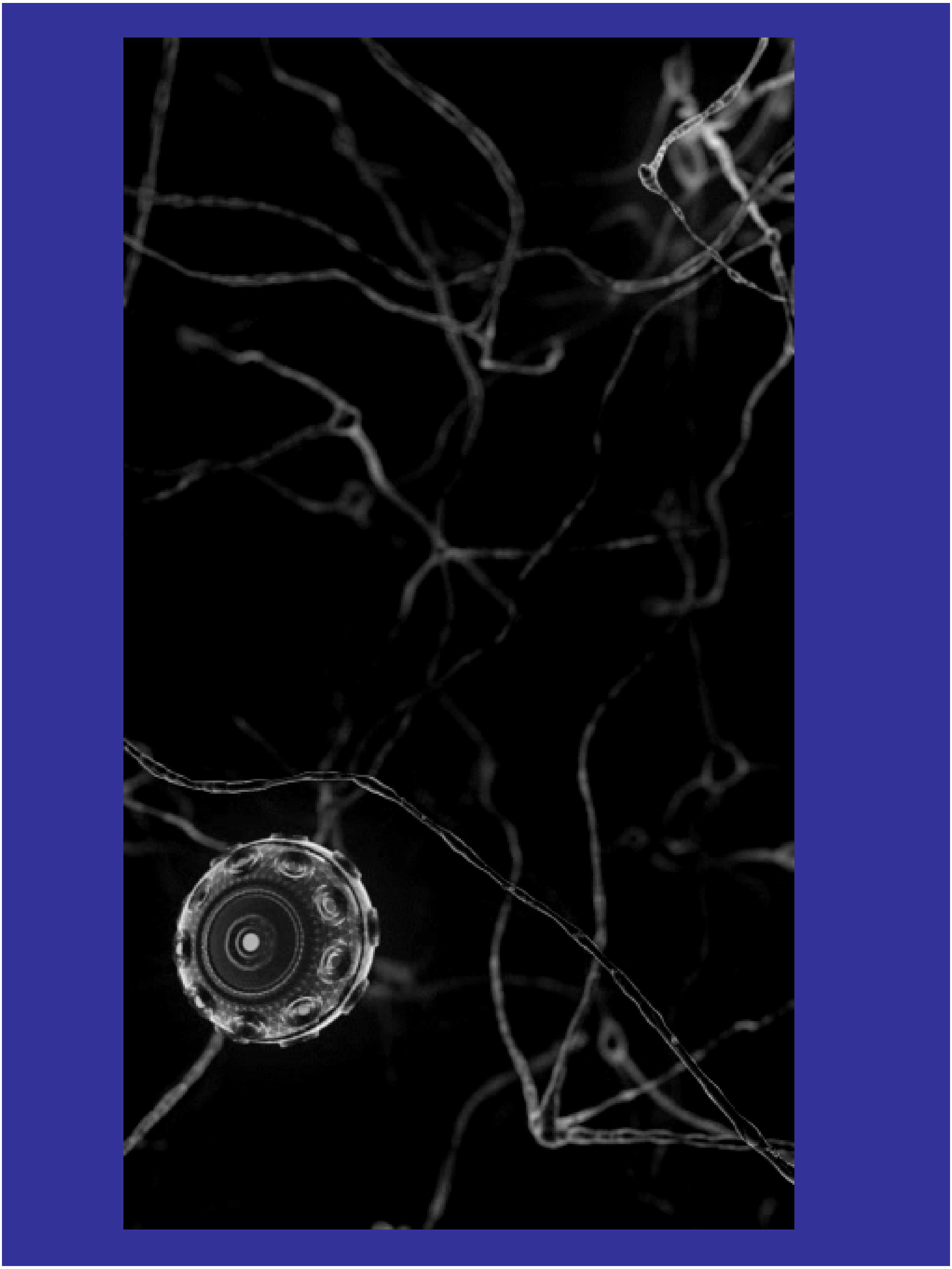
Outer shell made of strong, chemically inert diamond

Up to 10 trillion nanorobots, each as small as 1/200th the width of a human hair might be injected at once

Adapted from Time Magazine, Nov. 1999 by A. P. Tomsia

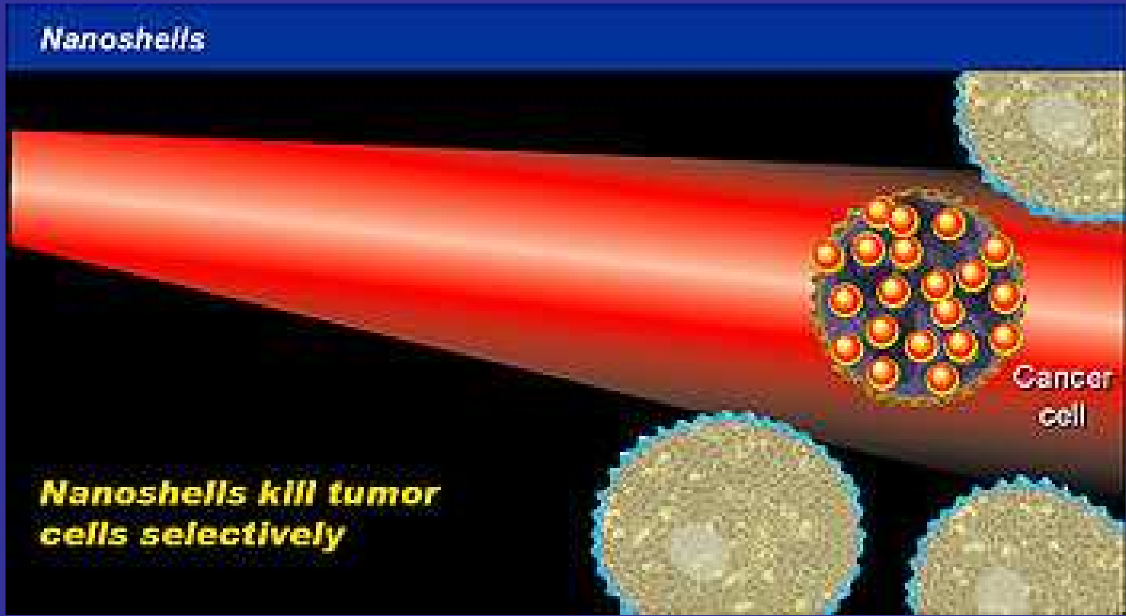
The Allure of Nanotechnology

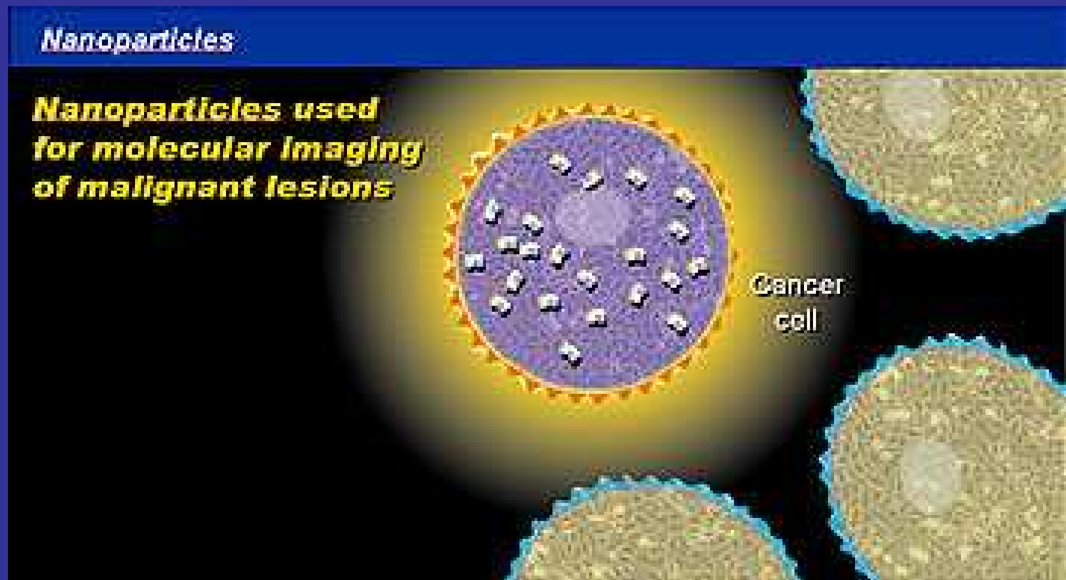




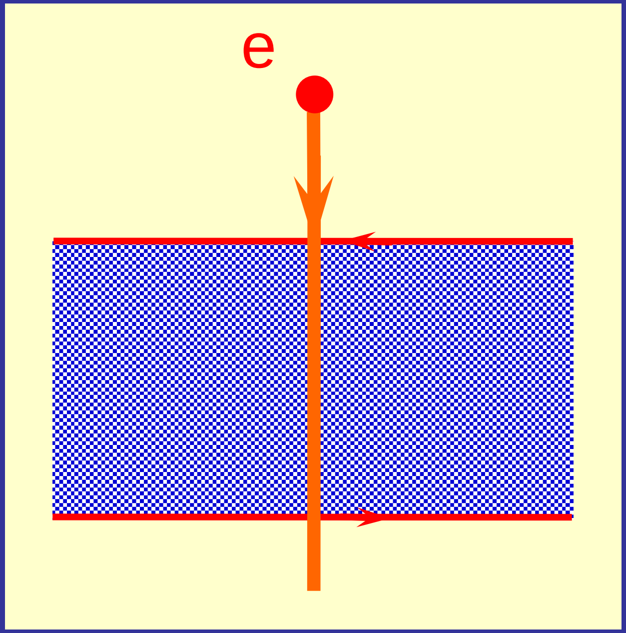
“The future of oncology and the opportunity to eliminate the suffering and death due to cancel- will hinge on our ability to confront cancer at its molecular level”

Andrew von Eschenbach.(former director of the US National Cancer Institute (NCI) in Bethesda, Maryland).

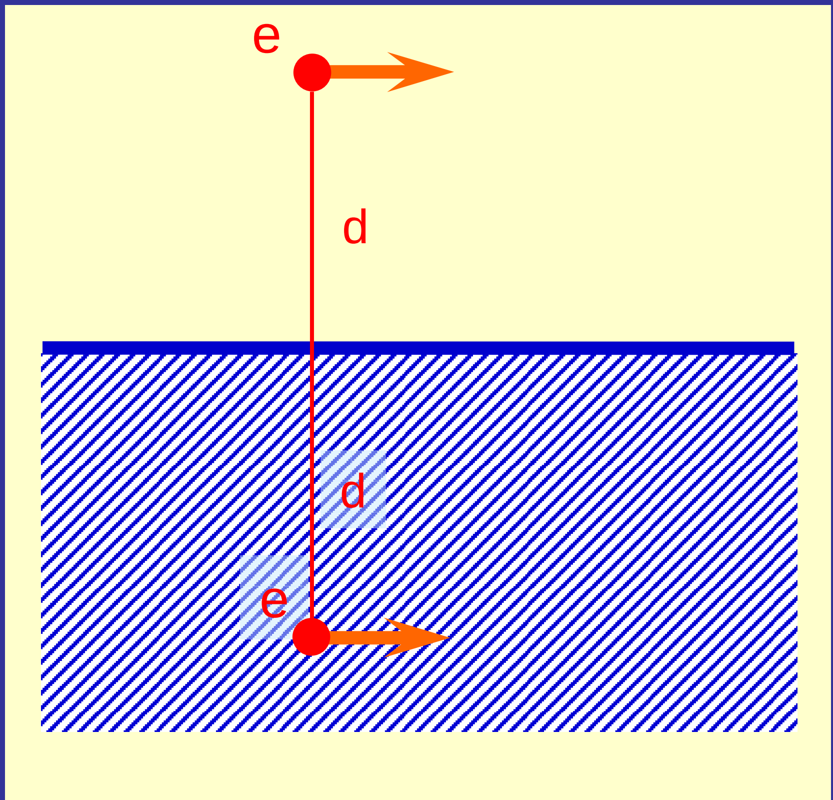

Nanoshells
Nanoshells kill tumor cells selectively
Cancer cell


Nanoparticles
Nanoparticles used for molecular imaging of malignant lesions
Cancer cell

"Plasma Losses by Fast Electrons in Thin Films"
R.H.Ritchie, Phys. Rev. **106** (1957) 874.



- Reduction of Loss at ω_p
- New Loss at a "lowered" plasma frequency



$$-\frac{dW}{dx}=\frac{\omega_{sp}^2}{u^2}K_0\left(\frac{2\omega_{sp}d}{u}\right)$$

P.M.E. & J.B.Pendry, J. Phys. C **8** (1975) 2936.

$$-\frac{dW}{dx}=\frac{\omega_p^2}{u^2}ln\left(\frac{2u^2}{\omega_p}\right)-\frac{\omega_p^2}{u^2}K_0\left(\frac{2\omega_p d}{u}\right)+\frac{\omega_{sp}^2}{u^2}K_0\left(\frac{2\omega_{sp}d}{u}\right)$$

R.Nuñez, P.M.E., & R.H.Ritchie, J. Phys. C **13** (1980) 4229.

"RITCHIE has noted for a semi-infinite plasma that there exists not only the bulk plasma oscillations of the classical frequency in the interior of the plasma, but also surface plasma oscillations, the quanta of which we will call surface plasmons, at the interface between the plasma and vacuum of a frequency $\omega_p / \sqrt{2}$."

E.A.Stern & R.A.Ferrell, Phys. Rev. **120** (1960) 1.

The Ritchie's frequency: $\omega_{sp} = \dfrac{\omega_p}{\sqrt{2}}$

"... After delivering my paper, he (Birkhoff)* was startled at the vociferous criticism of my work from a prestigious English Physicist (later a Nobel Laureate) in the audience. He had worked on the same problem but did not find the surface plasmon."

Ritchie's account

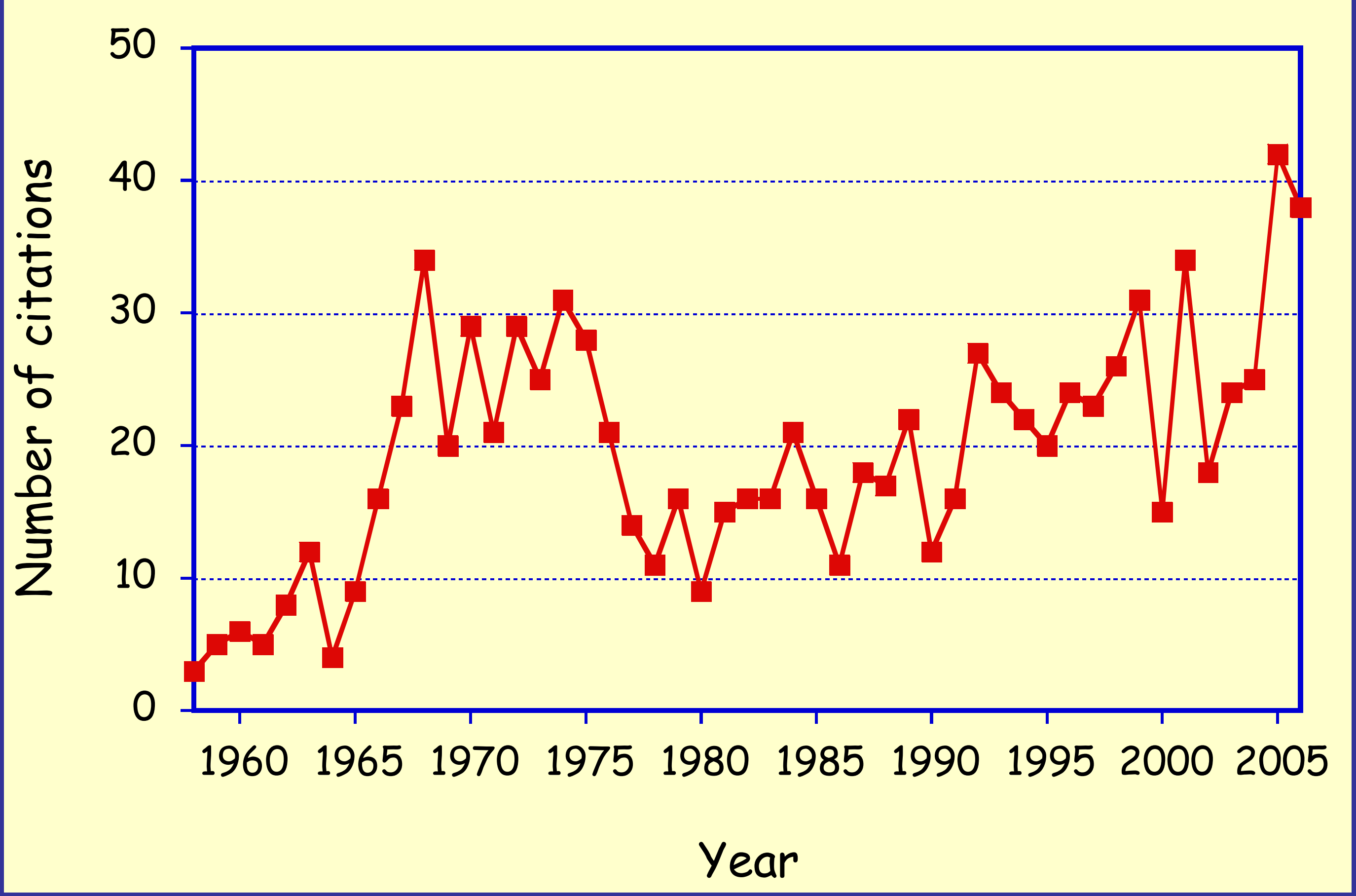
* Who first presented Ritchie's work in a meeting at the University of Maryland.

"I studied the paper of my English critic* and decided that he had not found surface modes in the bounded plasma because he had required that the electric field of the modes should vanish at the surfaces. In fact he had discussed only the volume plasmons in a bounded medium."

*D. Gabor, Philos. Mag. **1** (1956) 1.

"Plasma Losses by Fast Electrons in Thin Films"
R.H.Ritchie, Phys. Rev. **106** (1957) 874.

Third week in January of 1985. "This Week's Citation Classics"
Current Contents, November 3, Jan 21, 1985, p. 18.



At the time of the Citation Classic, Ritchie's paper have been cited over 435 times.
By now around 1000.

Surface plasmon

Key role in fundamental and applied research

- Van der Waals forces
- Energy transfer in gas-surface interaction
- Surface energies
- Surface vibrational modes damping
- Energy loss
- De-excitation of adsorbed molecules
- Surface dynamics
- Surface-plasmon microscopy
- Surface plasmon resonance technology
- Optical transmission in photonics
- Scanning Transmission Electron Microscopy (STEM)

- Electrochemistry
- Wetting
- Biosensing
- Scanning tunnelling microscopy
- Ion ejection from surfaces
- Nanoparticle growth
- Surface-plasmon microscopy
- Surface-plasmon resonance technology
- Optical transmission in photonics

Recent review: J.M.Pitarke, V.M.Silkin, E.V.Chulkov, P.M.E., Rep. Prog. Phys. **70** (2007) 1.

Renewed interest in surface plasmons:

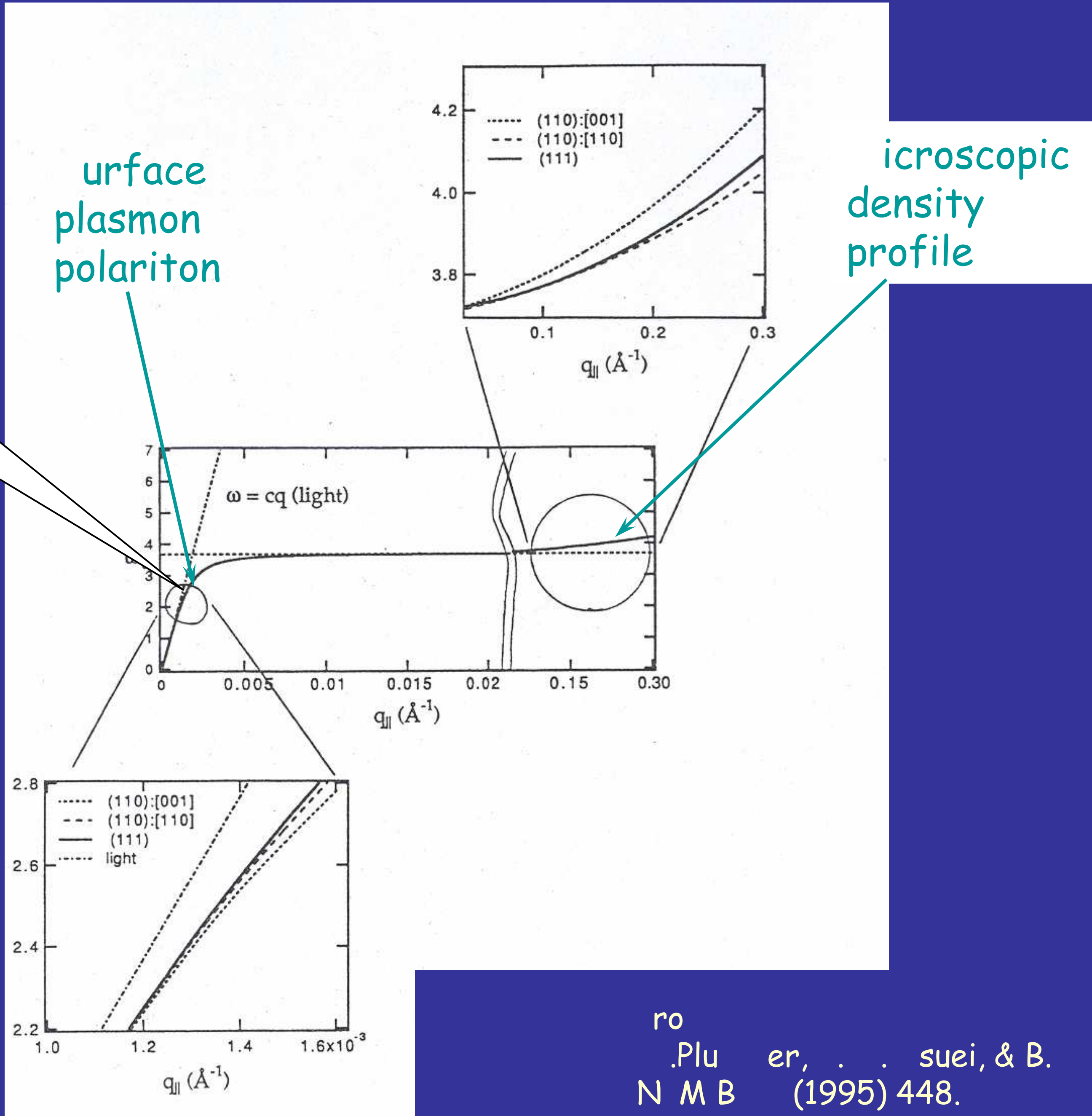
Nano-optics and **Plasmonics**

• Ability to squeeze light into nanostructures (resonant enhancement of plasmonic field in subwavelength structures)

- Metamaterials
- Surface-enhanced spectroscopy
-Nano-scale biosensors

Time resolved- Petek

$$q = \frac{\omega}{c}\left(\frac{\varepsilon_1\varepsilon_2}{\varepsilon_1+\varepsilon_2}\right)^{1/2}$$



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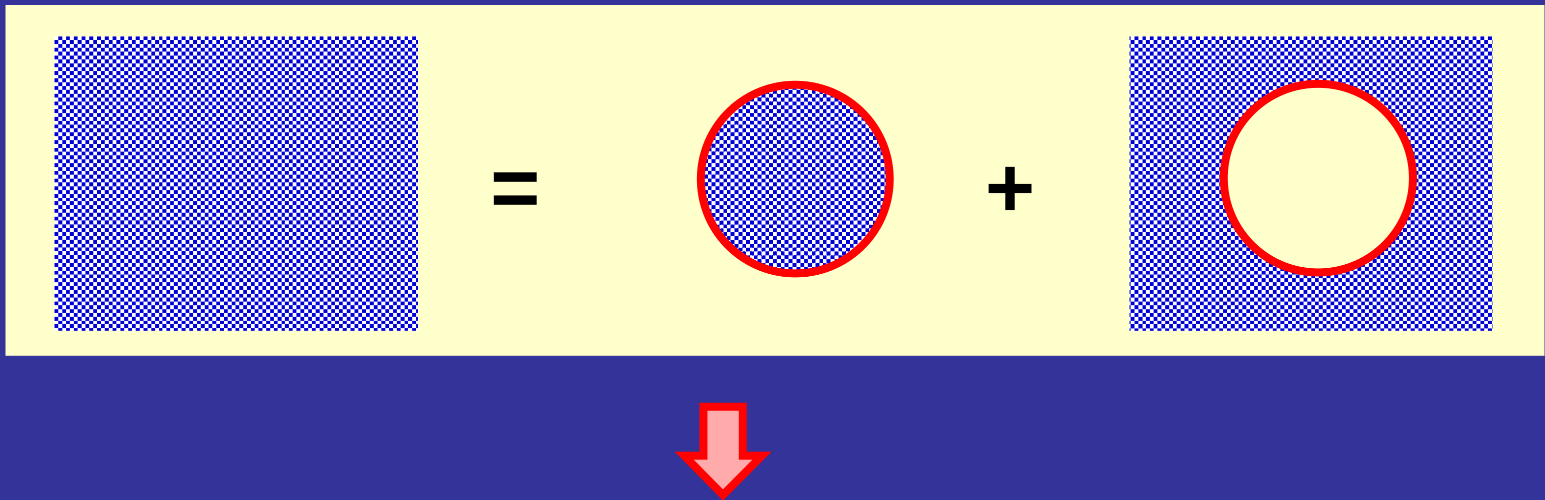
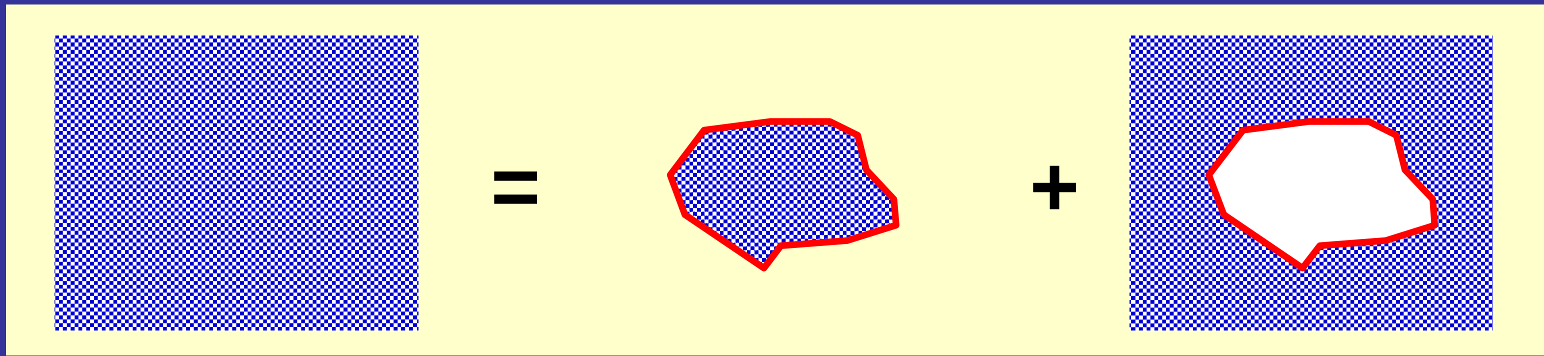
.Plu er, . . suei, & B. . i ,
N M B (1995) 448.

Sum rules - classical limit

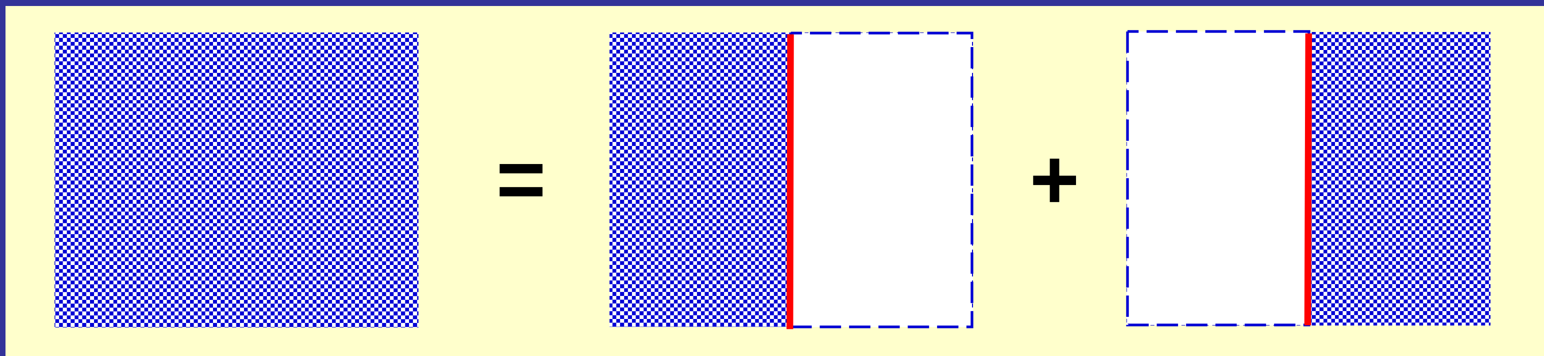


$$\omega_p^2 = \frac{\omega_p^2 \ell}{2\ell + 1} + \frac{\omega_p^2 (\ell + 1)}{2\ell + 1}$$

Sum rules - classical limit

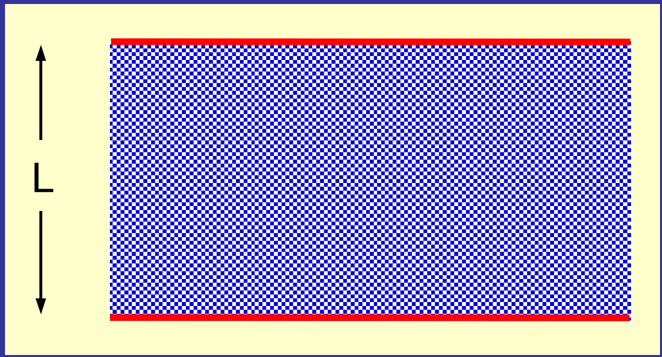


$$\omega_p^2 = \omega_1^2 + \omega_2^2$$

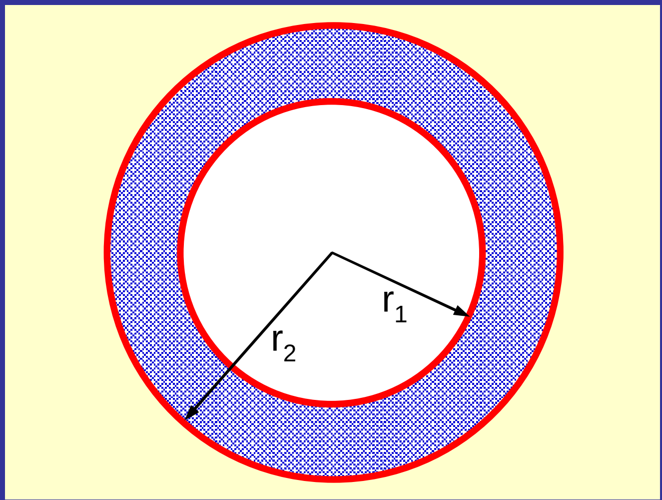


$$\omega_{sp} = \frac{\omega_p}{\sqrt{2}}$$

Sum rules - classical limit



$$\omega_{a,b}^2 = \frac{\omega_p^2}{2}\left(1 \pm e^{-qL}\right)$$

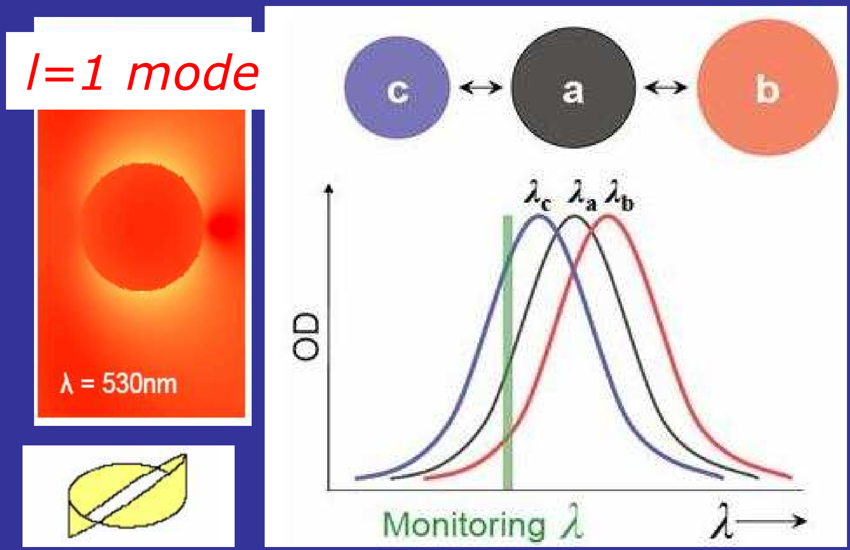


$$\omega_{a,b}^2 = \frac{\omega_p^2}{2}\left(1 \pm \frac{1}{2l+1}\sqrt{1 + 4l(l+1)(r_1/r_2)^{2l+1}}\right)$$

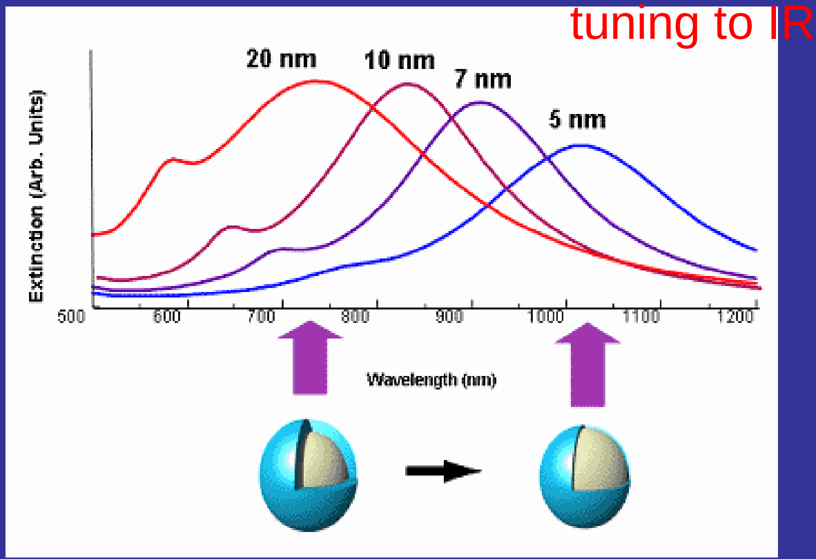
S.P.Apell, P.M.E., & R.H.Ritchie, Ultramicroscopy **65** (1996) 53.

Plasmons for near-infrared therapy of cancer

Spherical plasmon (λ=530nm)



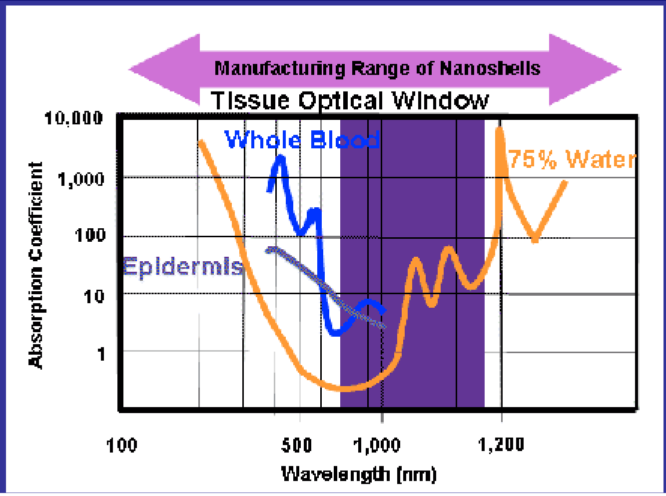
Nanoshell plasmons (infrared)



Plasmons in the near infrared thanks to nanoshell tuning ➔

Functionalisation of the nanoshells to be attached to cancer cells ➔

IR Absorption ➔ high temperature ➔ destruction of cancer cells



Nanotechnology with plasmonics:

Before the nanorevolution

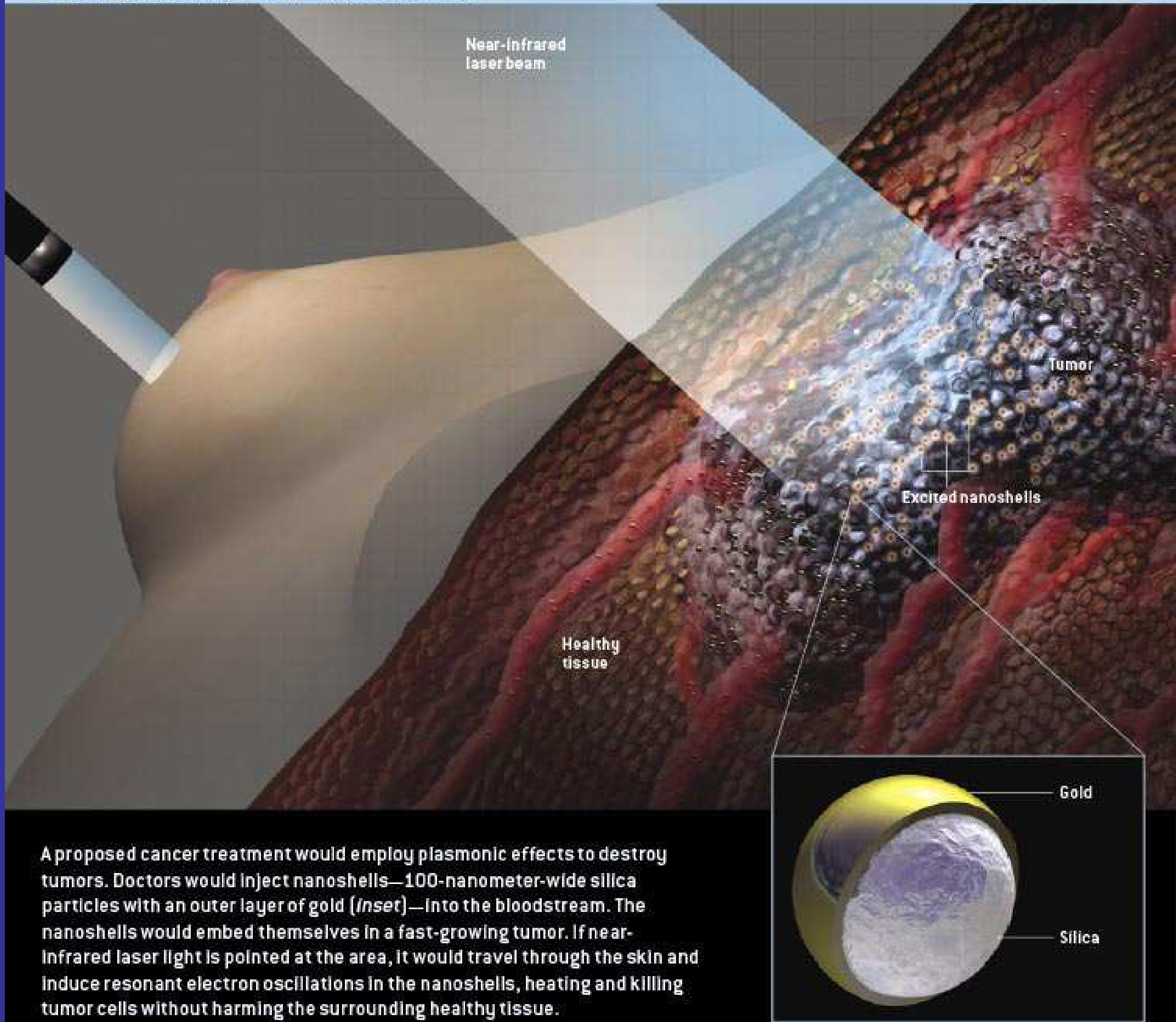
"Labors of the Months"
(Norwich, England, ca. 1480)

Lycurgus Cup
(British Museum; 4th century AD)

Illumination: from outside from inside

Strong absorption at and below 520 nm

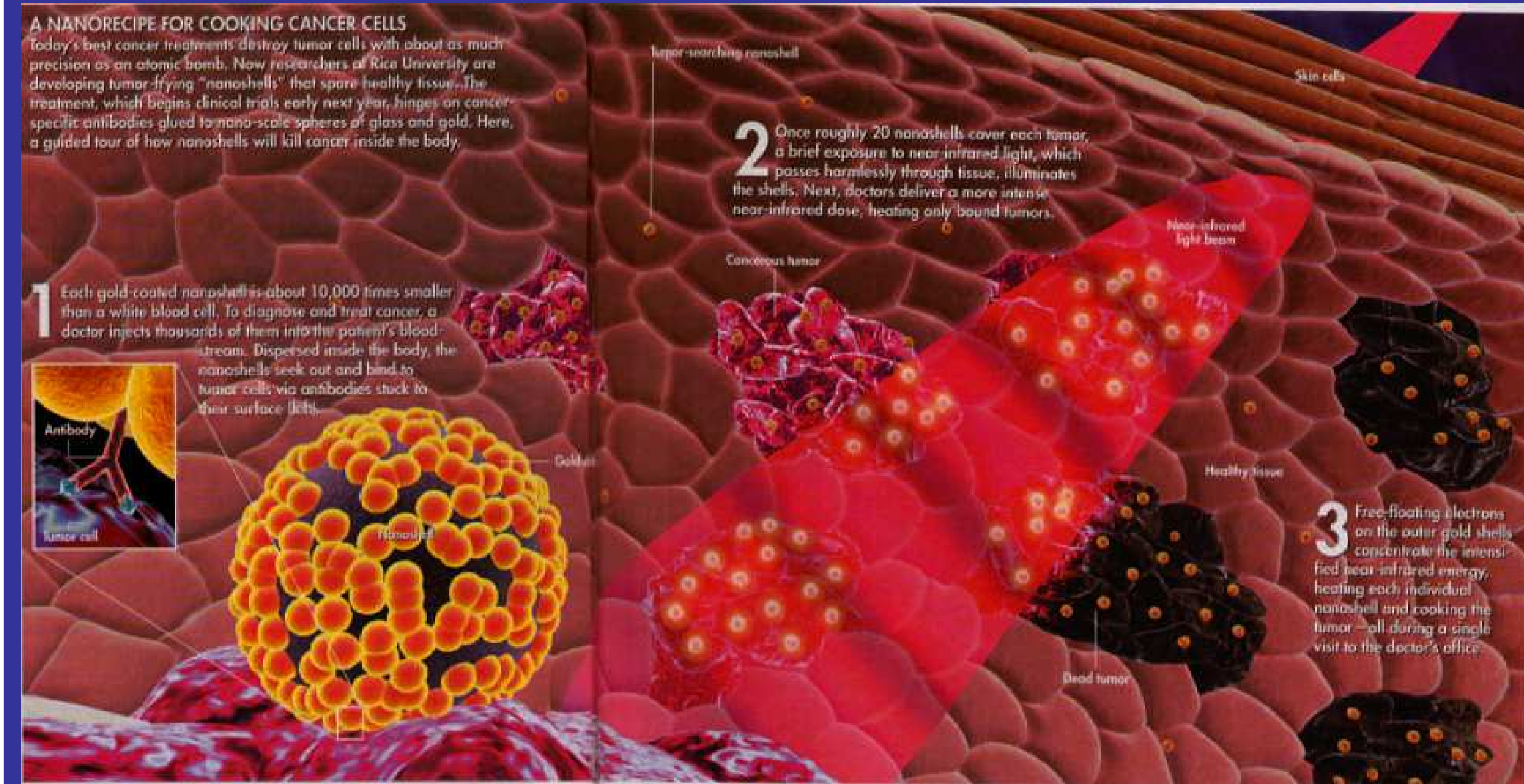
PLASMONIC THERAPY FOR CANCER



A proposed cancer treatment would employ plasmonic effects to destroy tumors. Doctors would inject nanoshells—100-nanometer-wide silica particles with an outer layer of gold (*inset*)—into the bloodstream. The nanoshells would embed themselves in a fast-growing tumor. If near-infrared laser light is pointed at the area, it would travel through the skin and induce resonant electron oscillations in the nanoshells, heating and killing tumor cells without harming the surrounding healthy tissue.

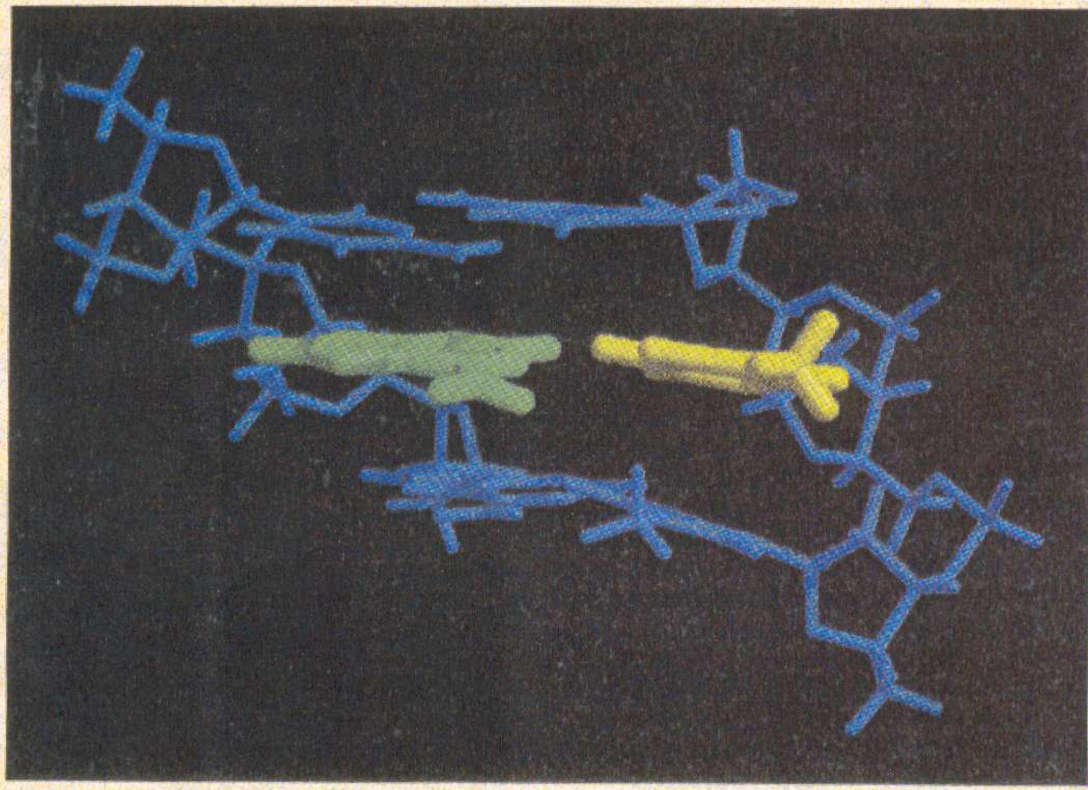
PHIL SAUNDERS *Space Channel Ltd.*

Activadores farmacológicos



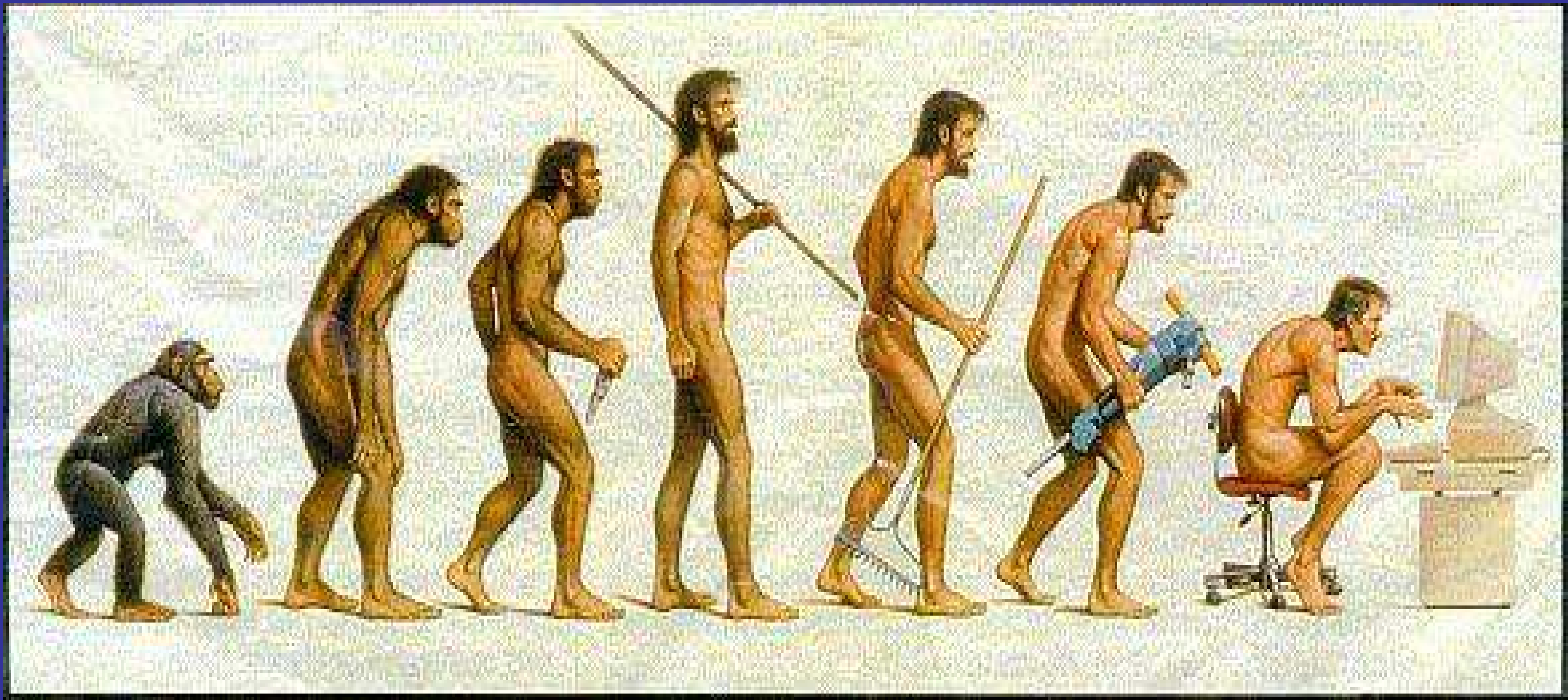
Grupo de N. Halas y P. Norlander, Rice University, EEUU

Nonnatural base fits into DNA double helix



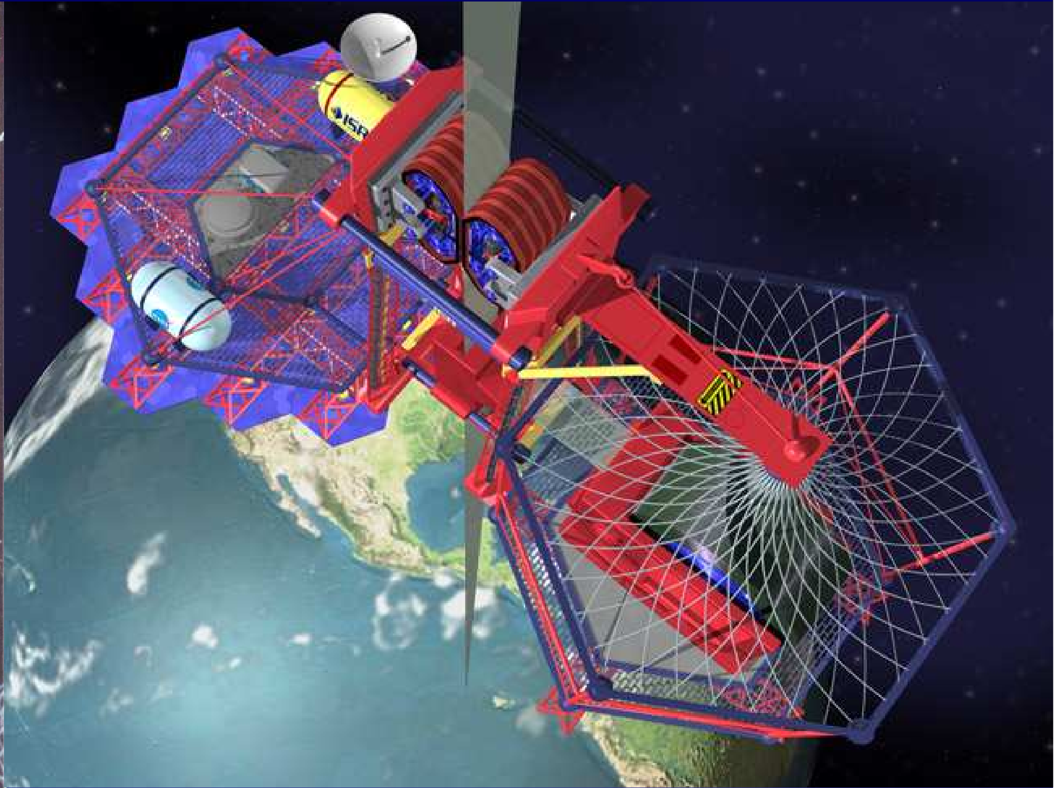
Courtesy of Eric T. Kool

Difluorotoluene (yellow) mimic of the natural base thymine forms a base pair with adenine (green) within 12-base-pair DNA duplex. The pair is essentially indistinguishable from a natural thymine-adenine pair in DNA, despite little or no ability of difluorotoluene to form hydrogen bonds with adenine.



Nanotechnology: a higher form of evolution?
(Humility is perhaps appropriate…)

El ascensor espacial !!!



"At the third annual international conference on the space elevator being held in Washington, D.C. (2204), scientists and engineers are tackling hurdles that must be overcome for the concept to, quite literally, get off the ground"

Arthur C. Clarke (1978) "Fountains of Paradaise"