

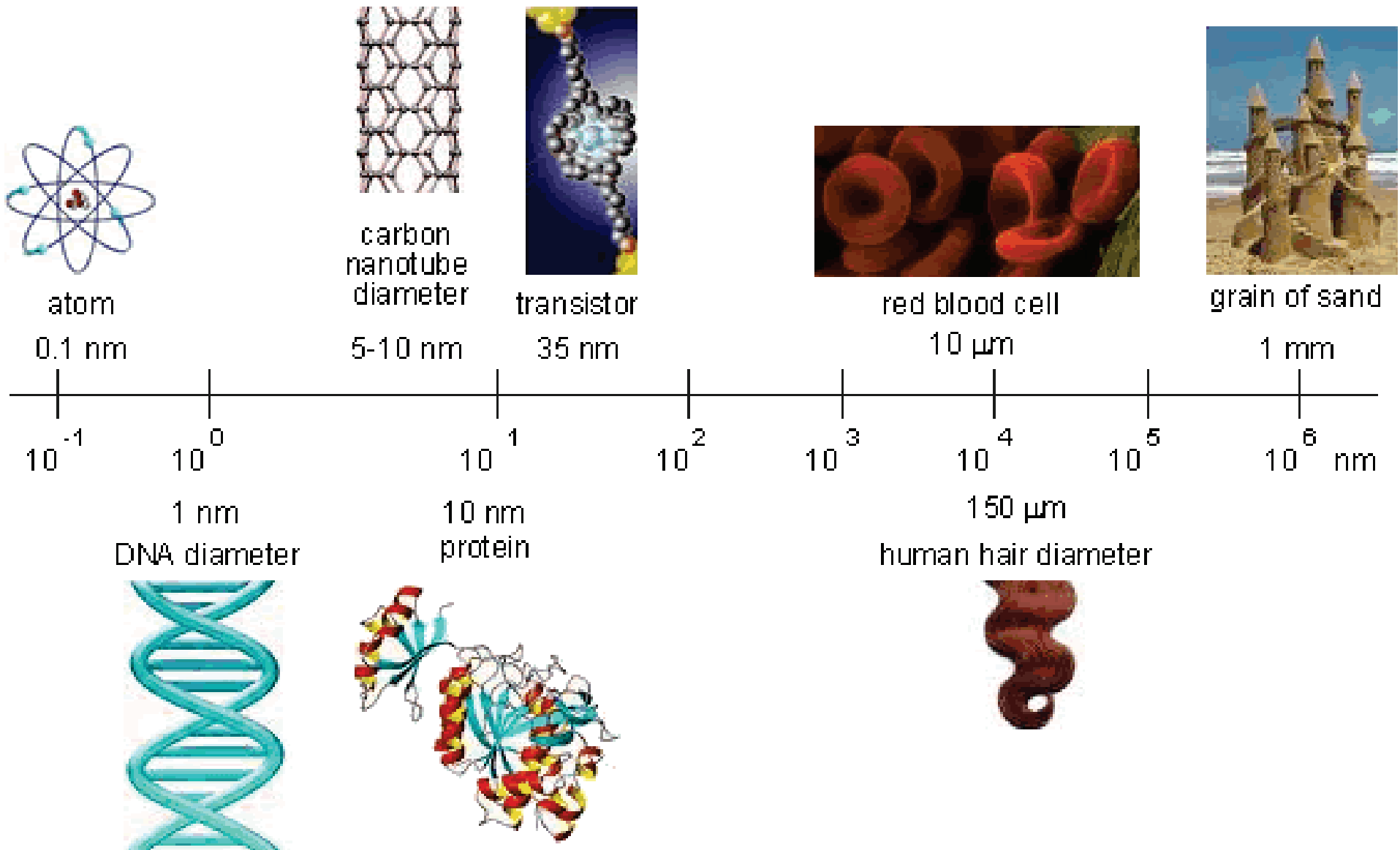
What is *Nanotechnology*?

Making, Measuring, Manipulating,
all at nanometer scale.

1 inch = 25,400,000 nanometer

1 human hair = 150,000 nanometer

Nano-scale: *how small is 1 nanometer?*



National Nanotechnology Initiative

<http://www.nano.gov/>

“Imagine the possibilities: materials with ten times the strength of steel and only a small fraction of the weight -- shrinking all the information housed at the Library of Congress into a device the size of a sugar cube --- detecting cancerous tumors when they are only a few cells in size.

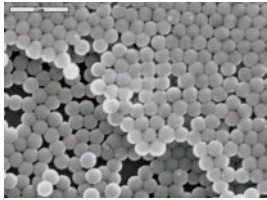


President William J. Clinton
January 21, 2000
California Institute of Technology

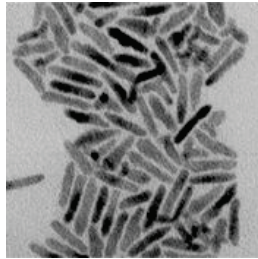
Nano-Quote:

- **\$32 billion** in nanotechnology sale, 2008.
- **\$2.6 trillion**, by 2014.
- **\$2 billion**, federal budget for Nanotechnology R&D, 2009.

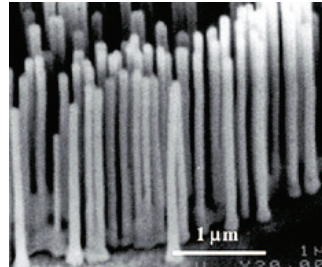
All kinds of 'Nano'



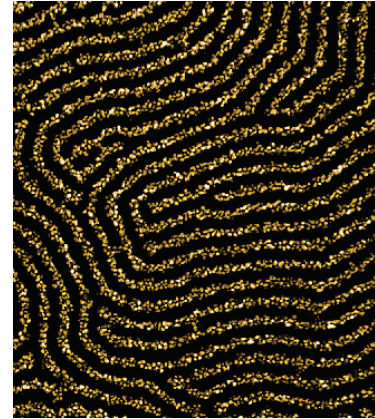
Nanosphere
Nanoparticle
Quantumdot



Nanorod



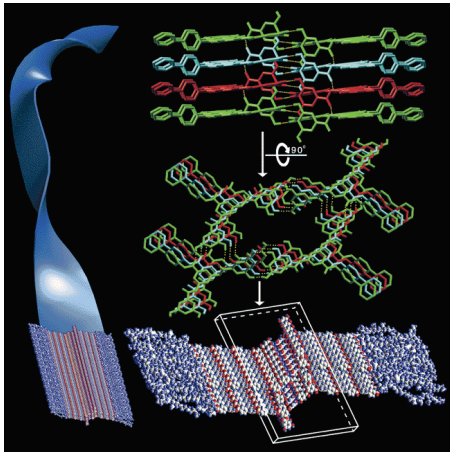
Nanowire



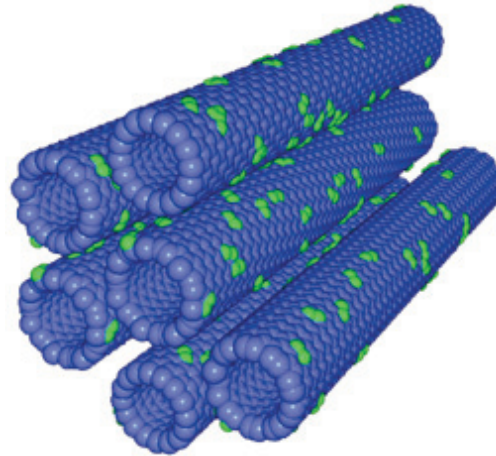
Nanochain



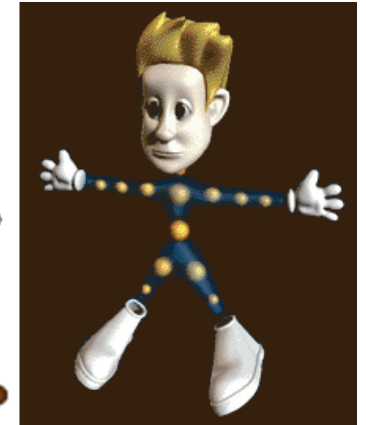
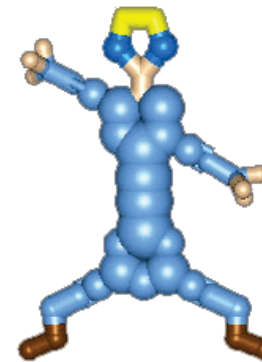
Nanobelt



Nanoribbon

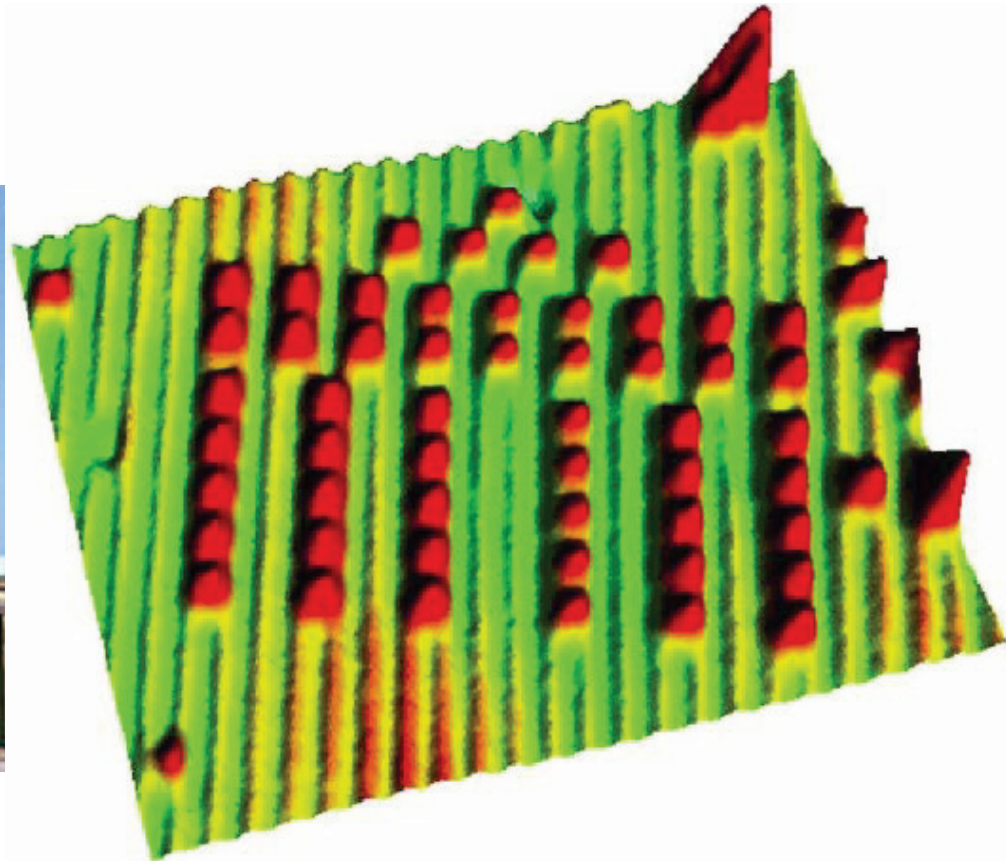


Nanotube

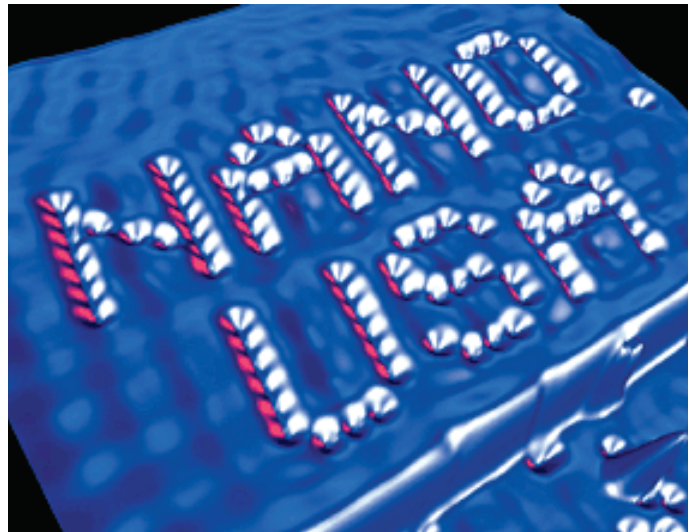
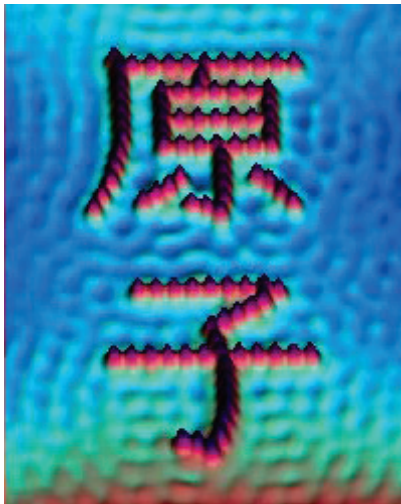
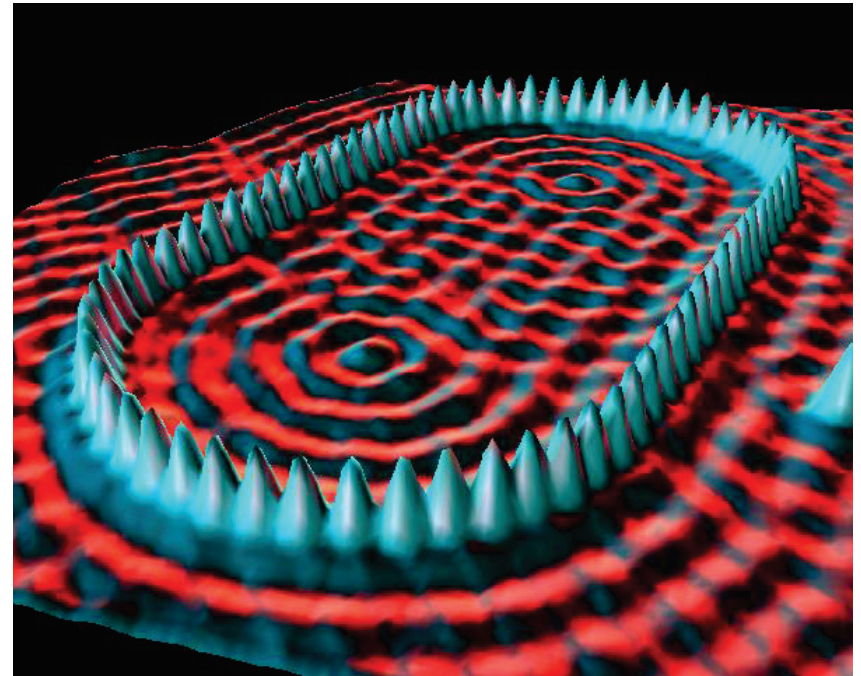
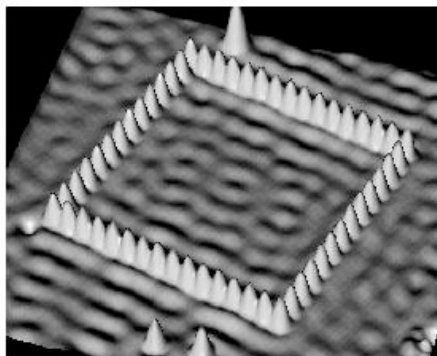
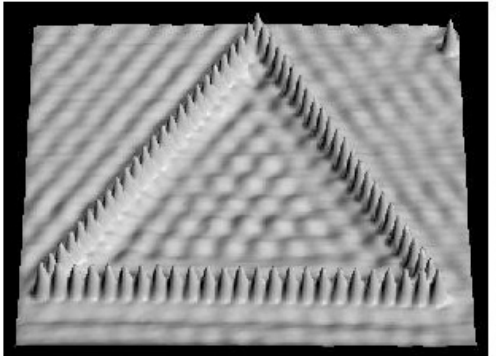
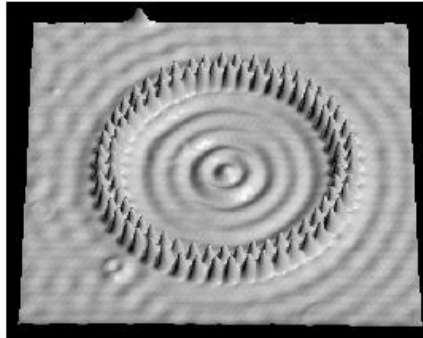
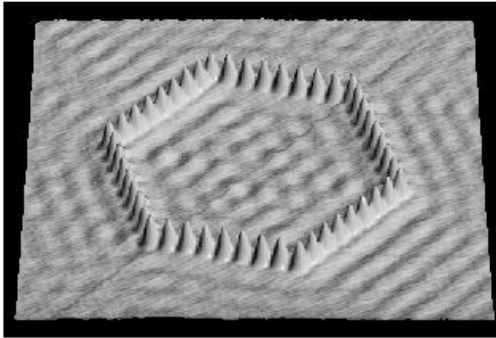


Nanokids

Brandenburg gate constituted by CO molecules



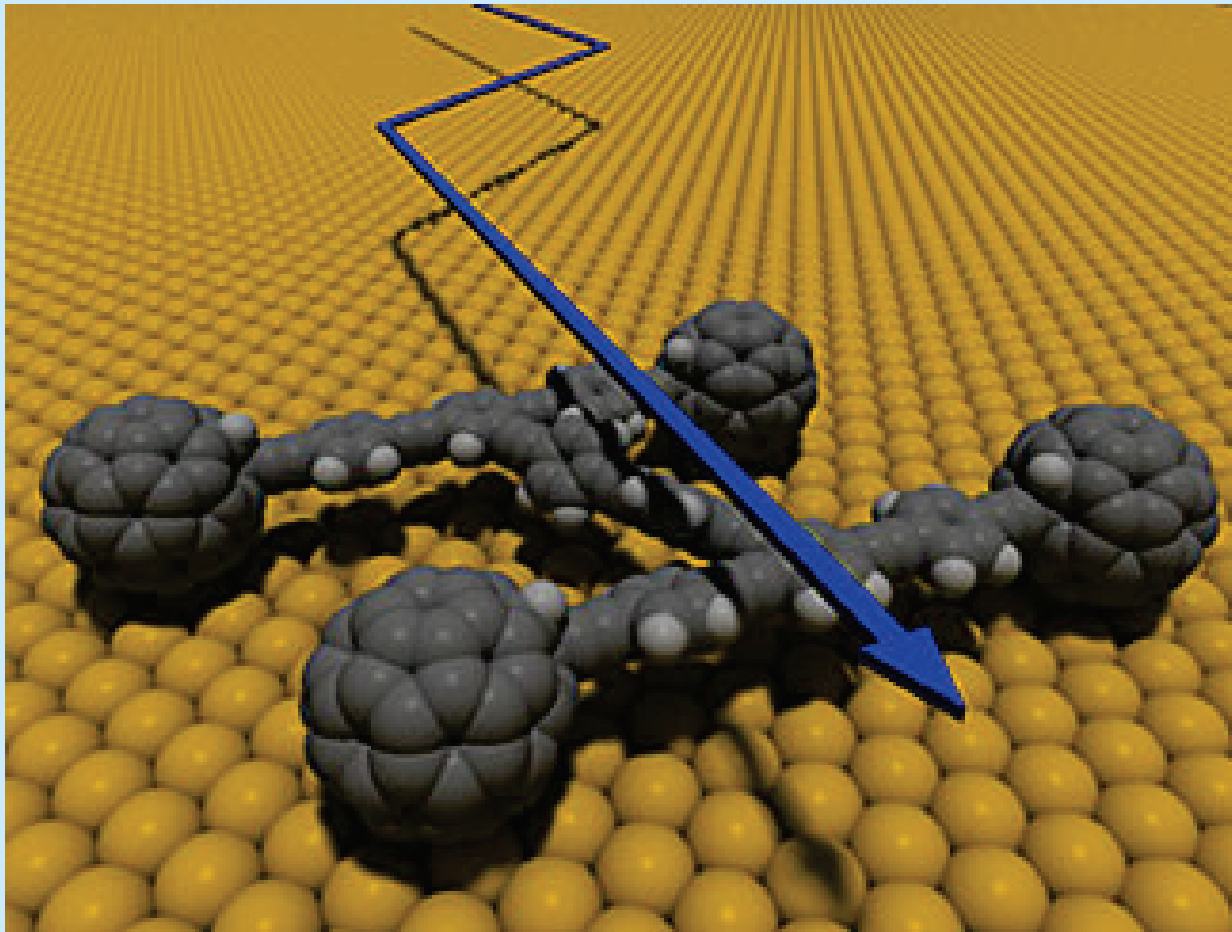
Pattern Single Atoms



Is that small?
Is that possible?
Is that cool?

Nanocar Rolls Into Action

World's first molecular car zips about on fullerene wheels



NANOTECHNOLOGY: THE NEXT BIG THING

*U.S. National Nanotechnology Initiative
aims to create another Industrial Revolution*

William Schulz
C&EN, Washington

By anyone's measure, nanotechnology is the next big thing. In fact, according to government R&D planners, nanotechnology is nothing short of the next Industrial Revolution.

But to keep the ball rolling, government planners will also have to keep alive the drumbeat of promise about the fruits of nanotechnology research. By their own estimate, government R&D analysts say, payoffs from significant investments in nanotechnology are at least 20 years away.

"We are constantly faced with 'How do we keep this going through the system?'" says Duncan T. Moore, the Administration's point man for nanotechnology in the White House Office of Science & Technology Policy (OSTP). As with any cross-agency government program, he says, the President's recently announced National Nanotechnology Initiative (NNI) will likely face many challenges over the next decade that it is scheduled to be in operation.

"A lot of the old barriers [between R&D agencies] have been broken down," Moore says, to jump-start the nanotechnology initiative. Six of the nation's largest R&D agencies—the National Science

the initiative, he says. What's more, the Administration has requested an extra \$495 million in funding for those agencies' NNI programs in fiscal 2001. Details of how each agency involved with NNI will carry out its portion of the initiative can be found at <http://www.nano.gov>.

The initiative got its official start in August 1999 when the National Science & Technology Council's (NSTC) Interagency Working Group on Nanoscience, En-

feel confident that legislators will support the initiative. With varying degrees of success, he says, OSTP took the same approach with its cross-agency initiative for information technology research.

When NNI was officially unveiled last year by NSTC—a subunit of OSTP that coordinates cross-agency research initiatives—it was accompanied by a strategic public relations plan. NSTC, for example, hired science writer Ivan Amato to pen a glossy brochure entitled "Nanotechnology: Shaping the World Atom by Atom."

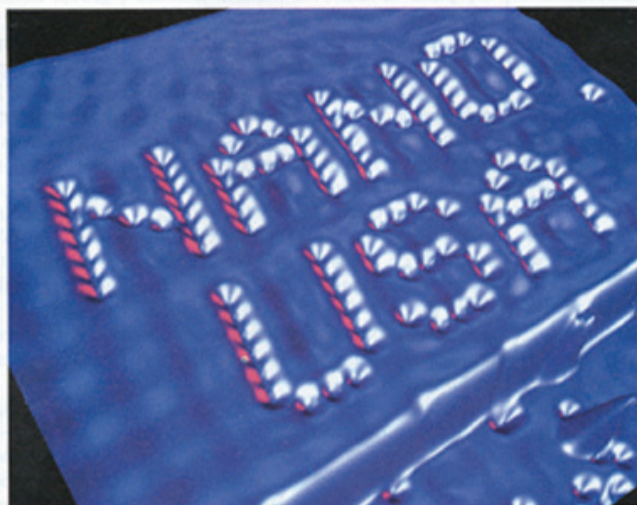
In the brochure, Amato sets forth a basic definition of nanotechnology—generally, the world as it works on the nanometer or "billionths" scale—and it lays out the following vision: "What could we humans do if we could assemble the basic ingredients of the material world with even a glint of nature's virtuosity? What if we could build things the way nature does—atom by atom and molecule by molecule?"

Because nanotechnology involves the control of matter at the atomic or molecular level where quantum effects must be taken into account, it is often a difficult subject even for fellow scientists to grasp, Moore says. The brochure and other outreach methods, he continues, are "much like NIH saying, 'This is basic research, and it is to be applied to X, Y, and Z disease categories.' And that's an easier thing to sell to my neighbor."

That strategy has garnered outside support, and it appears to be having an impact. The initiative, for example, was the focus of an American Chemical Society "Science and the Congress"

luncheon briefing on Capitol Hill to help acquaint members and congressional staffers with the field of nanotechnology and its promise.

Entitled "Tiny Dynamite: The Nanotechnology Revolution," the briefing received approval from the scientific community

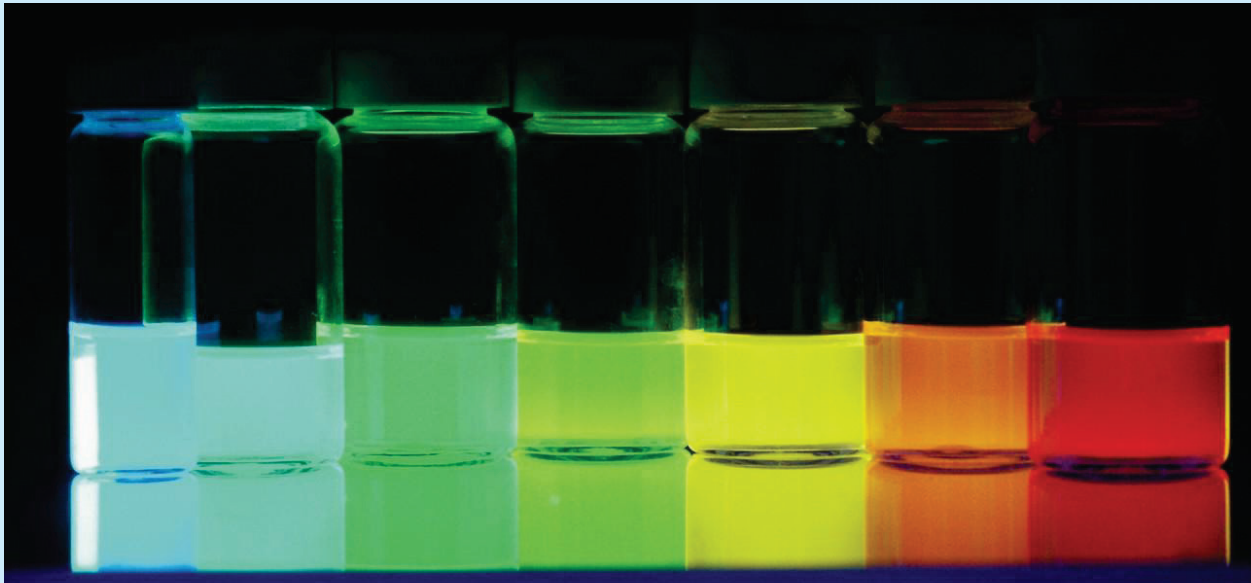
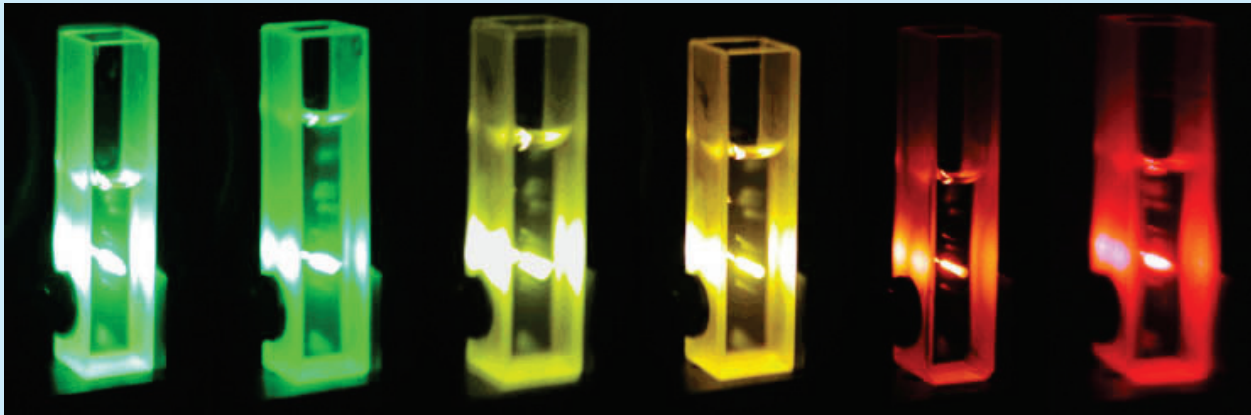


This image of 112 carbon monoxide molecules on a copper surface was made at IBM's Almaden Research Center using a scanning tunneling microscope. Each letter is 4 nm high by 3 nm wide. About 250 million nanoletters of this size could be written on a cross section of a human hair; this corresponds to 300 300-page books. President Clinton used the image to unveil NNI.

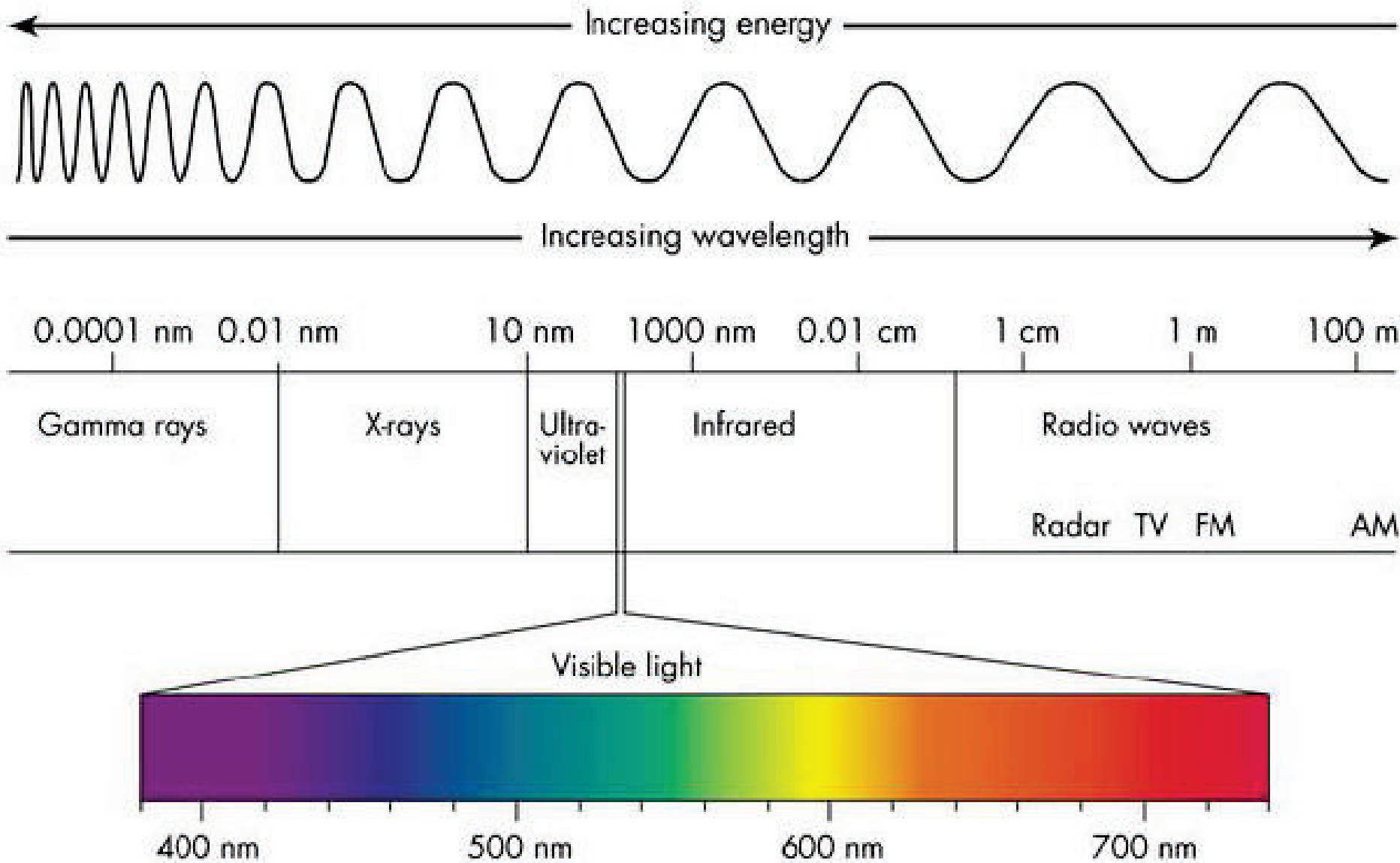
gineering & Technology released its first report, "Nanostructure Science & Technology." It is, the authors say, a blueprint for the federal government to assess how to make strategic R&D investments in nanotechnology.

Of the many challenges

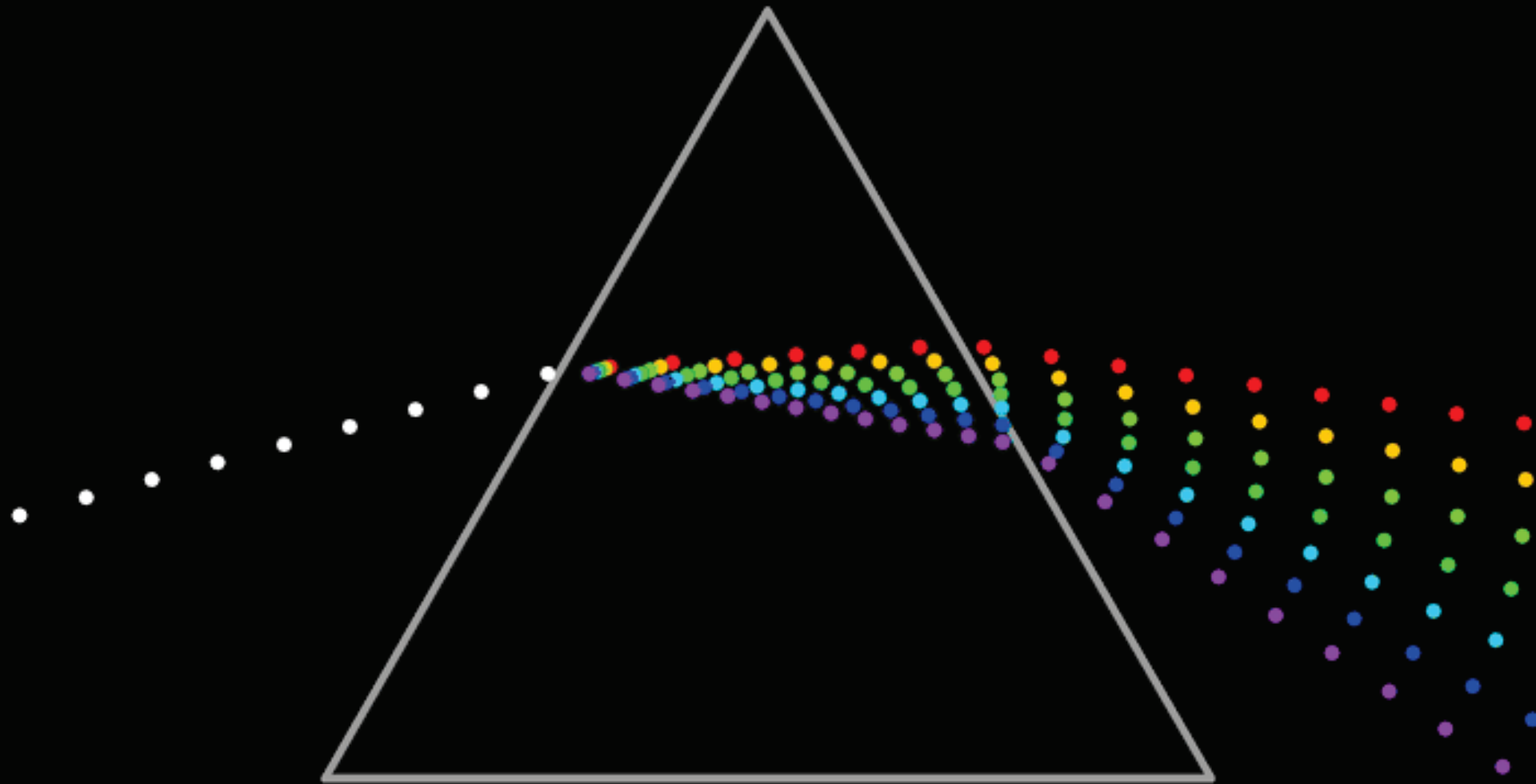
Changing emission color by changing the particle size



2.3  5.5
Size (nanometers)



The Electromagnetic (Radiation) Spectrum



Splitting white light through a prism

Organic Light-emitting diode (OLED) devices:

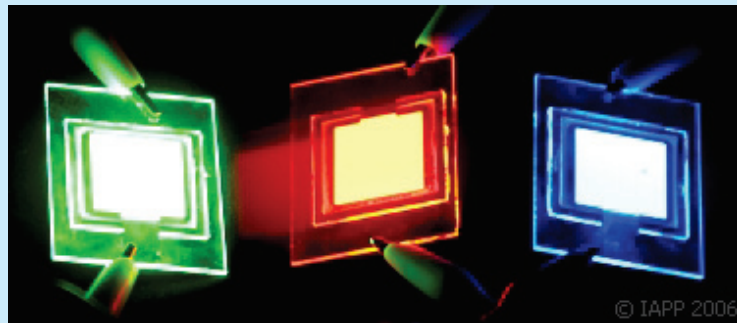
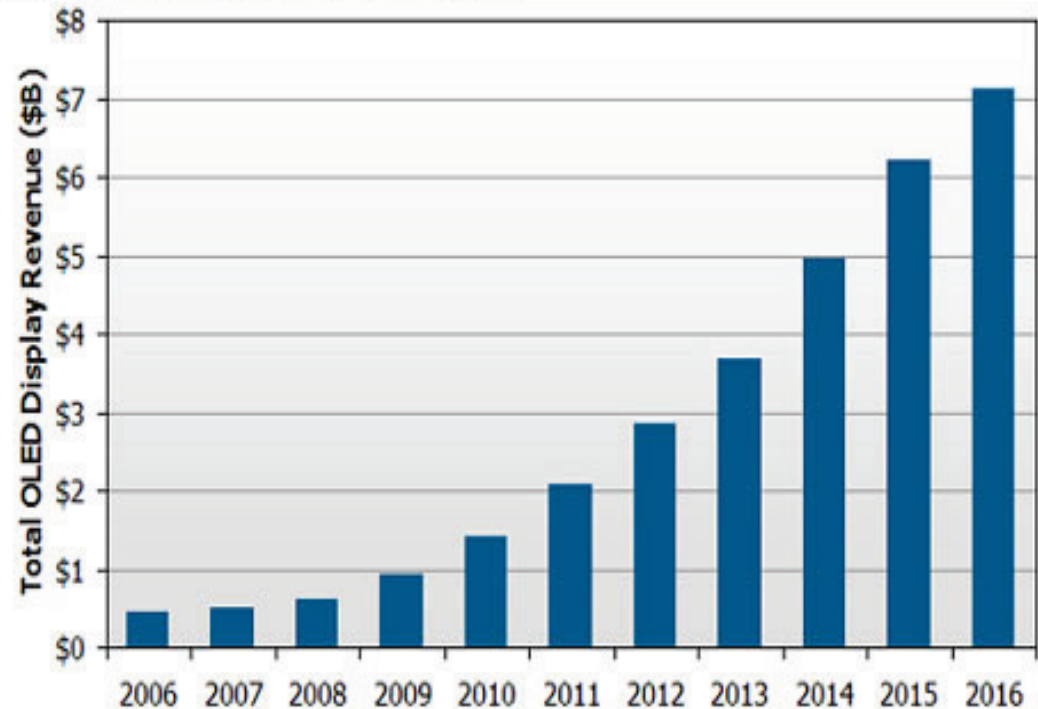


Figure 1: OLED Display Revenue Forecast



Source: DisplaySearch Q2'09 Quarterly OLED Shipment and Forecast Report

OLED TV: *never cool like this*



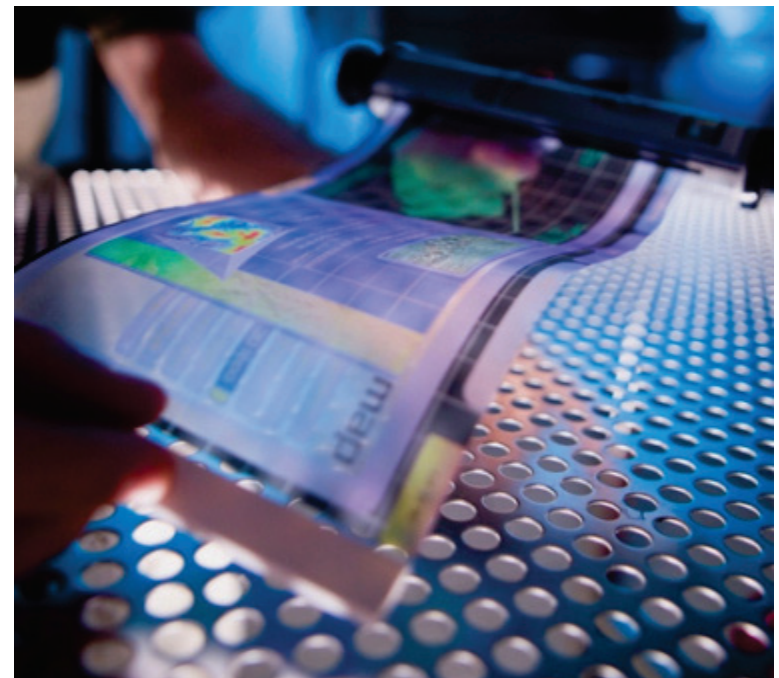
Thin: millimeter

Flat: full view angle

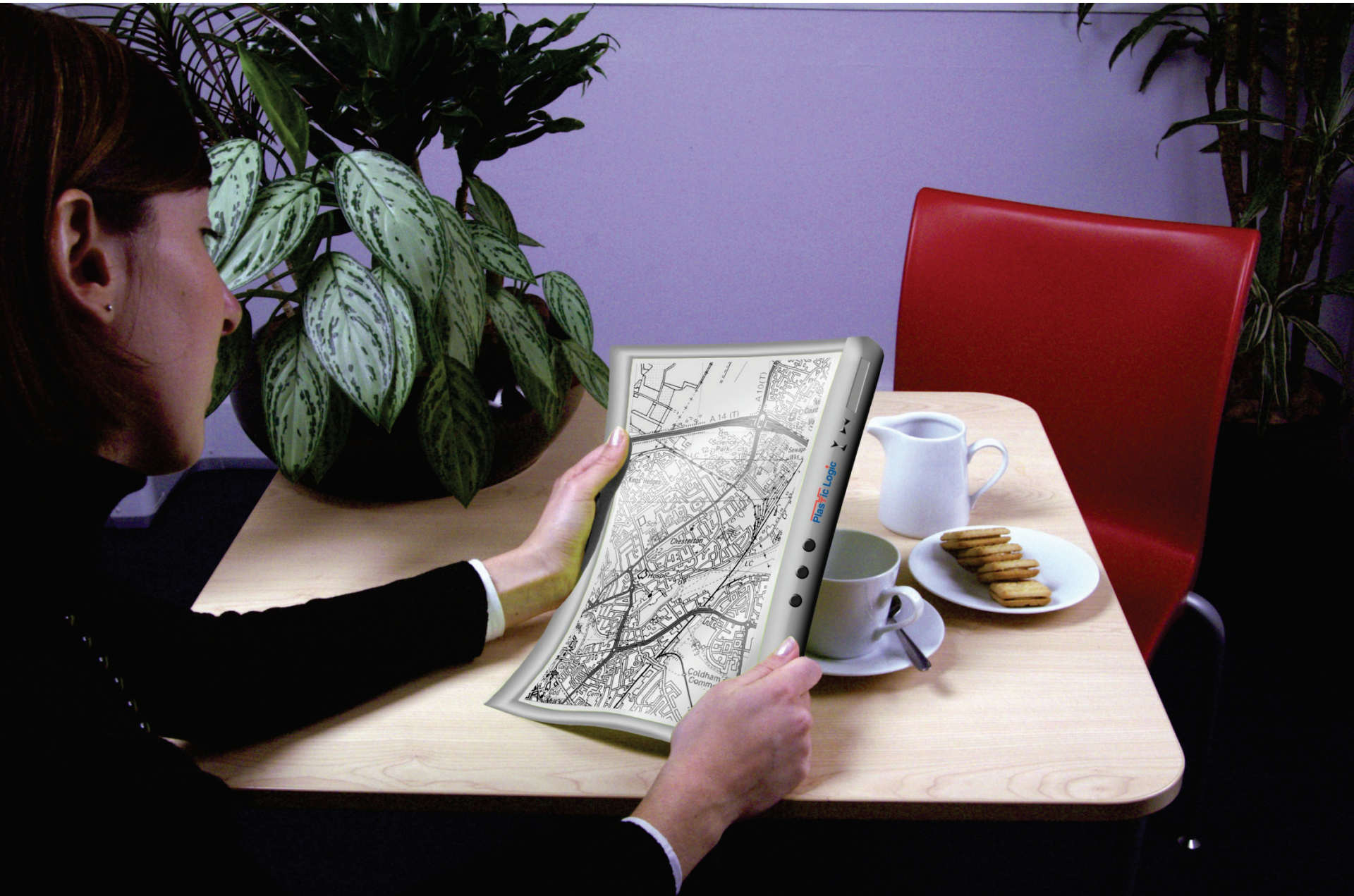
Bright: 1,000,000:1

and ...

Flexible, foldable !



E-book: *fold it as you like*



Breaking Through

Printable electronics is attracting growing interest and is gearing up for commercial applications

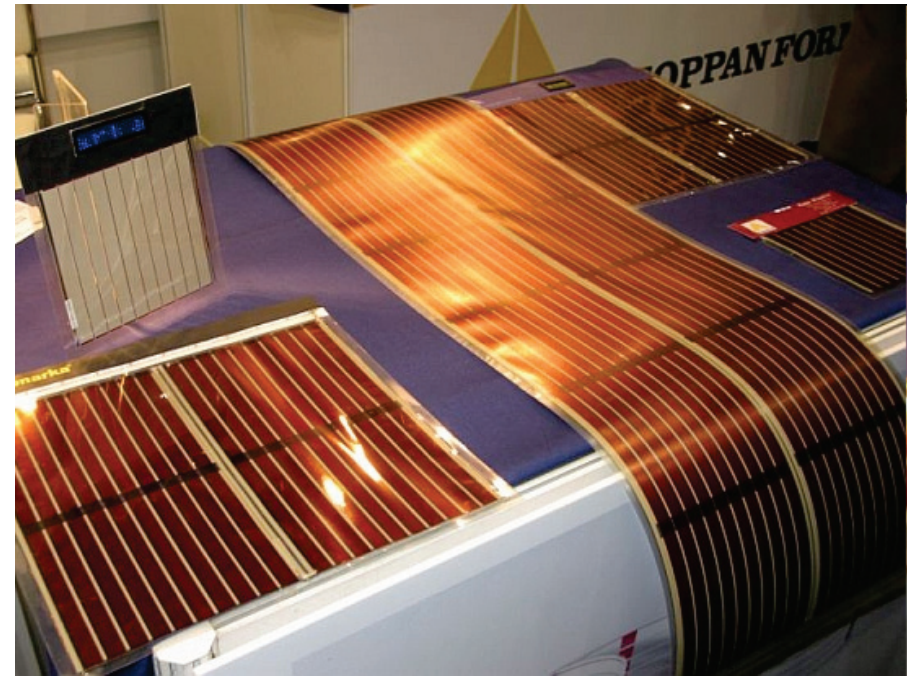
[Alexander H. Tullo](#)

Why organic (plastic)?

Cheap: \$\$\$

Flexible: in shape

Coatable: like paint



Solar cell powered windows:

Hong Kong Science Park



One day, power your house by painting solar cells



One day, power yourself using solar cell paints ...

