

cit  EXPO
des sciences & de l'industrie **NANO**
LA TECHNOLOGIE PREND UNE
NOUVELLE DIMENSION
La Villette - 20 mars > 2 sept



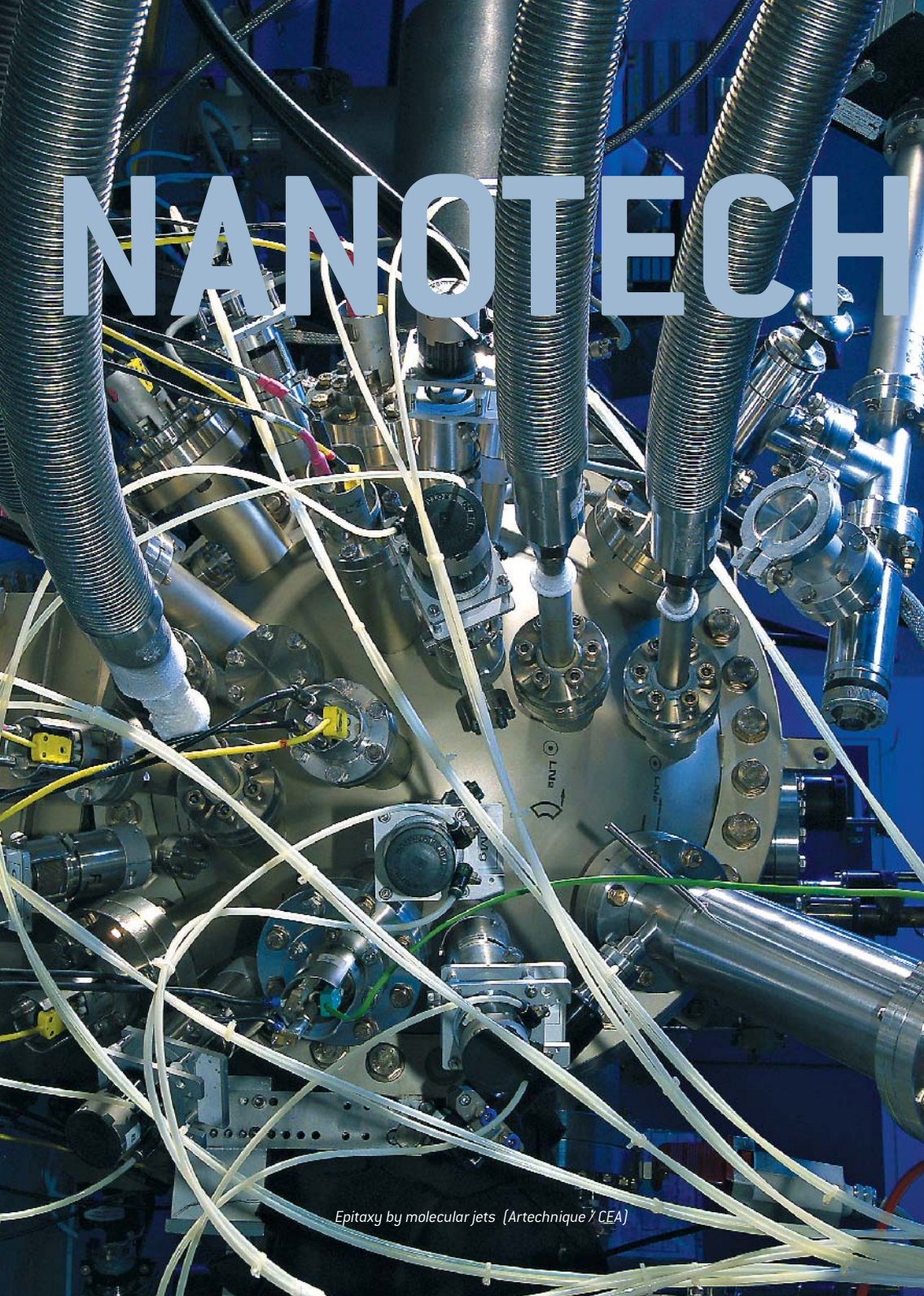
VISITOR GUIDE

coproduced by:



In partnership with:





NANOTECHNOLOGIES

What is it really about?

“EXPO NANO” explains to you in four sections the foundations, techniques and uses of nanotechnologies, together with the ethical issues that they raise.

What do we call “nanotechnologies”? They are techniques that now allow us to “see” and manipulate atoms and thus make new atomic structures.

There are numerous applications in every field: medicine, computing, the physics of materials, etc.

Amongst others, new products described as “intelligent” are already on the market: self-cleaning windows, graffiti resistant paints, etc.

These infinitesimally small technologies are promising: new methods of research linking a several disciplines (biology, chemistry, physics, computing), new therapies, new markets, etc.

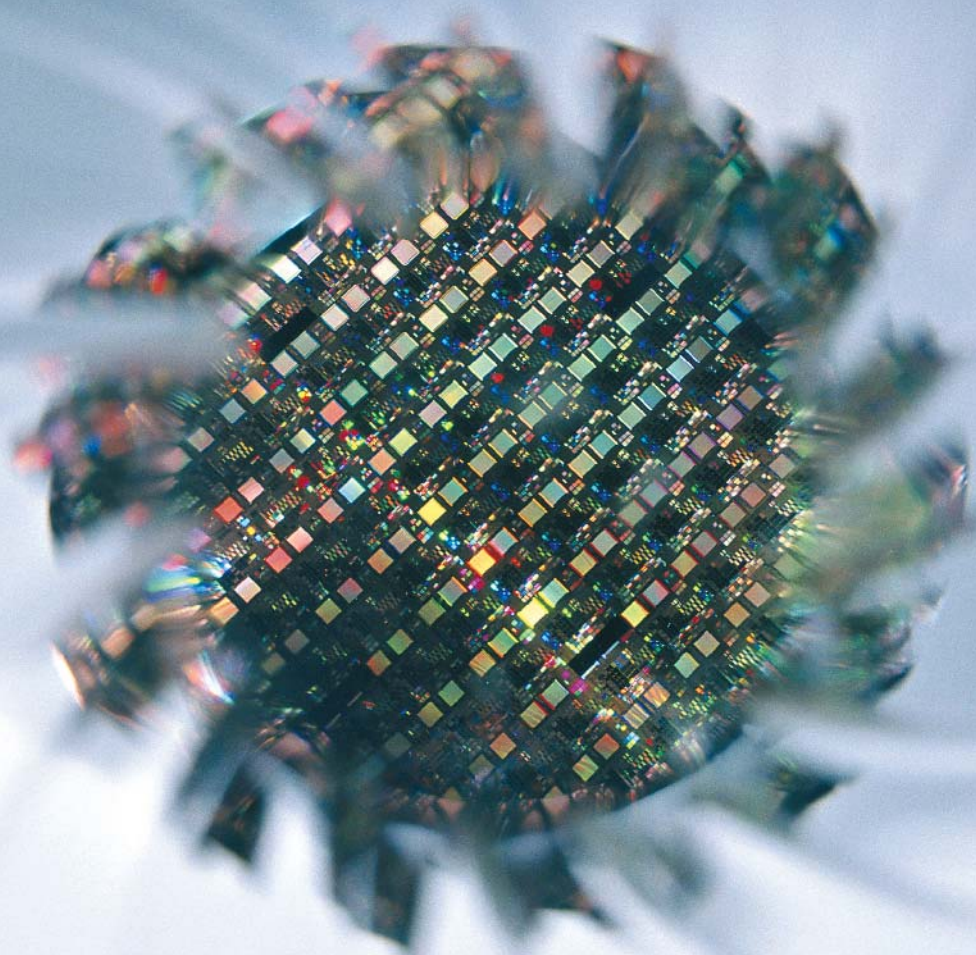
But like any technological advance, “nanos” raise a number of questions: What is their value to society? What are the risks for man, for the environment? Why would you want to modify matter?

“EXPO NANO” gives you the keys for you to form your own opinion and first and foremost, invites you to take a trip to the nanoworld ...

THE BASICS

I. THE BASICS

Enter the nanoworld...



Silicon insert (D. Sarraute / CEA)

1. The nanometre: a change of scale

- **The prefix “nano”** comes from the Greek word nanos, which means “dwarf”. Today it is joined to a great many words.

It is used especially in metrology (the science of measurement) when it divides by a billion the unit whose name it prefixes. For example: one nanosecond (1 ns), is a billion times shorter than a second.

- **One nanometre** (1 nm) is 30,000 times smaller than the diameter of a hair. It is at the scale of the atom or molecule (a group of atoms). One hydrogen atom measures about 0.1 nm.

2. The nanoworld: a change in the laws of physics

- **What we call the “nanoworld”** is the world of atoms and molecules: the world of the infinitesimally small.

- In the nanoworld, **the laws of quantum physics** replace the laws of traditional physics.

E.g. Imagine that you’re playing a game of “nano table football” and that the ball is an atom. It would move very slowly, or even not move at all, because the link between atoms is so strong that it’s difficult to separate them – matter “sticks together”.

1 nanometre (1 nm) = one billionth of a metre = 10^{-9} m = 0.000,000,001 m = 1/1,000,000,000 m.

3. The nanotechnologies: a change of properties

- **Nanotechnologies are** “newer than new” techniques that make it possible to manipulate and arrange atoms in a new way.

E.g. In nature, carbon atoms can spontaneously organise themselves into diamonds or graphite (coal). Today we can arrange them in a different way, in the form of a grid or a cylinder, for example, in order to obtain “carbon nanotubes” which give a material 20 times more rigid and 10 times lighter than steel, which is used to make some cycle frames.



1

- **These “new molecular forms”** obtained through the use of nanotechnologies, present new and valuable properties (thermic, electrical, etc.).

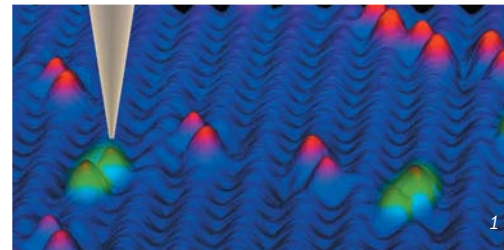
1/ hydrogen atom (CNRS / Cnet / Lactamme / J.-F. Colonna)

TECHNIQUES

II. TECHNIQUES Manipulating atoms

1. New observation instruments: the key to entering the nanoworld

- **In the past.** With scanning electron microscopes, you cannot see atoms.
- **Today.** In 1981, Gerd Binnig and Heinrich Röhler (Nobel Prize) invented the scanning tunnelling microscope. It is this instrument that enables us to “see” and manipulate atoms.
- **The limitation of instruments: their size.** The problem is that you are therefore working with instruments bigger than the objects you are manipulating. It's like sewing on a button wearing boxing gloves! We don't really yet know how to make “nano tools”.



2. The two avenues of research: “top down” and “bottom up”

The development of nanotechnologies is based on two complementary avenues:

- **“top-down” techniques** (i.e. from top to bottom), which is miniaturisation: existing materials are, in a way, “cut down” to make them smaller. Thus microelectronics become nanoelectronics. But this then means taking account of the new laws of physics at the nano scale;

- **“bottom-up” techniques** (i.e. from bottom to top), which is the fabrication of new structures by assembling atoms in a different way. So electronics will become molecular. The molecule will be used as a base component or integrated circuit.

3. The convergence of disciplines

Nanotechnologies bring several disciplines together: physics, chemistry, biology, electronics, etc.

In the United States they talk about NBIC convergence (nanotech, biotech, infotech and cognitive sciences):

- > **nanotechnologies** (all techniques at the atomic or molecular level);
- > **biotechnology** (includes genetic engineering);
- > **information technology** (with new methods of data processing, like the quantum computer);
- > **cognitive sciences** (whose ultimate aim is a complete understanding of how the brain works).

NBIC aims to improve, indeed modify, human capabilities and man's performance in general. In this almost science fiction vision, we would create an interface between the neuron and a microprocessor. Dream or nightmare ...?

USES

III. USES

They are already with us!

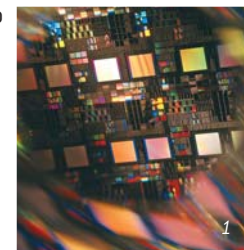
1. Nanomaterials and nanoproducts

Nanotechnologies have potential applications in every domain: health, energy, transport, communications, environment, defence, etc. The following developments are now envisaged:

- **constructing materials** with a minimum of raw materials and indeed without producing any waste;
- **fabricating memories** containing ten hours of video on a surface the size of a postage stamp;
- **carrying a patient's treatment** in an empty molecule which would release its contents direct to the cancerous cells without putting stress on the rest of the organism; etc.

More than 200 "nano" products are already on the market:

- **dirt-proof textiles**, because they are coated with a film of silver nanoparticles;
- **self-cleaning glass**, coated with thin layers of titanium oxide;
- **toothpaste** with calcium nanophosphate, which fills any minute fissures in the teeth;
- **lipsticks** with zinc oxide to make it longer lasting; etc.



2. What kind of technology user are you?

- **You mustn't confuse "usage" and "application"**. The application of a technology is neither good nor bad in itself - everything depends on how it's used.
- **In the field of ICT** (information and communication technologies), sociologists distinguish 4 types of user: **the enthusiast, the utilitarian, the social being and the resistant**.
- **Don't forget to do the test at the exhibition** to find out what type of "homo nanotus" you are!

3. The economic importance of nanotechnologies

- **At the macroeconomic level**. Some industrialised countries think of nanotechnologies as the next industrial revolution. They are investing huge sums: 8.4 billion dollars in 2004 (including 4.6 billion of public funds). France, with **187 million dollars**, is in sixth place and in fifth place in terms of publications and patents.
- **At the microeconomic level**. As a result of the increase in public and private investment and the number of companies and patents involved, nanotechnologies are increasingly influencing our socio-economic environment, both locally and globally: new occupations, new training and education, new research, etc.

A biochip - laboratory on a chip (P.Stroppa / CEA)

1/ silicon insert (D. Sarraute / CEA)

ETHICS

IV. ETHICS

Does the future need us?

1. Science ... fiction

• **Past futures?** The nanoworld is invisible and so mysterious and intriguing; it prompts ancestral fears and fantasies: fear of the sorcerer's apprentice, of man who thinks of himself as God, fear that man will become the subject of scientific experiments ...



• **Possible futures?** Science fiction links the imaginary with knowledge at a given period in order to predict the future. Nanotechnologies are at the heart of this combination of science and the imaginary. Michael Crichton's

novel, Prey, tells the story of living nanoparticles swallowing up all the Earth's carbon. This catastrophic scenario seems highly improbable, but nanotechnologies are not exempt from risk ...

2. Nanotechnologies in discussion

Jérôme Rose, research director at the CNRS (France's national research institute); Bernadette Bensaude-Vincent, director of the French history and philosophy of science centre; Louis Laurent, physicist; and Jean-Pierre Dupuis, professor of philosophy at the Ecole Polytechnique give their views on three fundamental questions:

• **What are the potential risks of nanotechnologies and what kind of precautions can be taken?** Risk of the toxicity of products after the end of their "life", the risk of contact with nanoparticles, etc. The effort

made to assess these risks should be pursued alongside the research and envisaged collectively on the precautionary principle.

• **What ethical questions are posed by the development of nanotechnologies?**

Are we sure that we will be able to control nature and harness molecules to serve us? Are we protected from "bad" uses of these techniques (invasion of privacy, even more effective weapons, etc.)?

• **What new relationships between science and society involve research and controversy?**

Communication between scientists, politicians and the general public should be conducted pro-actively and not re-actively through the media, exhibitions, a science café, etc. Everyone has a part to play and something to say.

3. Now it's your turn!

You too, can say what you think. Before leaving the exhibition, complete the questionnaire provided. Your answers will be passed on to the various people working in the nanotechnology sector.

events

To complement your visit to the exhibition, science explainers are running a workshop on the subject of nanotechnologies.

> *Free admission for visitors with an entrance ticket to the exhibition.*

documentary resources at the médiathèque (media library)

A selection of works on nanotechnologies can be consulted at the library throughout the period of the exhibition and on line on www.cite-sciences.fr/college. And from 5 June to 1 July 2007, documentary films about nanotechnologies can be viewed on a plasma screen.

> *Open access and free admission, 'médiathèque', level -1.*

debates

At the request of the ministries of research and industry, three round table discussions open to the public were held at the Cité des sciences on 19 and 20 March 2007 on the subject "Nanotechnologies: the debate so far, directions for the future". Scientists, industrialists and politicians have taken a view of the ideas that have emerged from previous discussions and collective work on this subject in France. The ministers closed these one day debates by explaining the government's position.

> *You will find these discussions on www.cite-sciences.fr/college*

AROUND THE EXHIBITION

on line symposia

Listen again and refresh your memory of the series of five symposia on the subject "Nanotechnologies: what are the challenges?" presented in January - February 2006 at the Cité des sciences college:

• "Nanotechnologies: what are they about?", with Catherine Bréchnignac and Arie Rip;

• "New materials: new risks?", with Christian Colliex, Annick Loiseau, Olivier Witschger and Hervé Arribart;

• "From microelectronics to molecular electronics", with Michel Brillouët, Françoise Roure and Gérard Dujardin;

• "Diagnosis and treatment: the nano revolution", with Bernadette Bensaude-Vincent, Patrick Couvreur and Maxime Dahan.

• "The ethical challenges of nanotechnologies", with Louis Laurent, Alexei Grinbaum and Claude Weisbuch.

> *on www.cite-sciences.fr/college*

web site

Set out on a trip into the nanoworld, to the heart of matter with: videos, events, interviews with scientists, etc.

And to prepare for or extend your visit to the exhibition: full details and summary of the exhibition, a "nano" glossary, selected documents, etc.

> *on www.cite-sciences.fr/nanotechnologies*

EXPO NANO

Technology takes on a new dimension

20 March > 2 September 2007

USEFUL INFORMATION

OPENING TIMES

Every day except Monday, 10 am to 6 pm (7 pm Sunday).

ADMISSION CHARGES

- Exhibition entry ticket: €8

(Concessions €6, under 25s and large families)

This ticket gives admission to other Cité exhibitions and associated events and to one performance at the Louis-Lumière cinema (3D film).

- Happy Hours: €3 from 3pm Tuesday to Friday on presentation of a student or ISIC card (until 31 August 2007).
- Under 7s admitted free.
- Disabled persons and accompanying carer admitted free.
- Unemployed and those on income support admitted free.

BOOKINGS

- At the Cité or online on www.cite-sciences.fr
- Réseau France ticket (€ 1.60 booking charge per ticket)
0 892 69 70 72 (€ 0.34/min),
Fnac, Carrefour, HyperU, Géant Casino and other stores

"GROUP & TRADE" BOOKINGS 01 40 05 12 12

HOW TO GET THERE

Metro: Station "Porte-de-la-Villette" (Line 7)

Bus : 75, 139, 150, 152, PC

Car park (pay): entrance Quai de la Charente

Cité des sciences et de l'industrie
30, avenue Corentin-Cariou, 75019 Paris

INFORMATION: 01 40 05 80 00 (voice server)

www.cite-sciences.fr



In partnership with:

