

**WELCOME TO THE NANOWORLD**  
**EPISODE 4**  
... NANOWORLDS AND MAXIFEARS ...  
**ENGLISH SCRIPT**

**OPENING TITLES - NANOWORLD**

**LA COMPAGNIE DES TAXI BROUSSE**  
PRESENTS

**WITH THE PARTICIPATION OF**  
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10 :00 : 00

**COMM**

All around us, around you, and me... the worlds of media, science and economy are resounding with the prefix « nano ». All I hear is references to this invisible scale, a billionth of a metre, just a few atoms wide...

The frenzy is global. Thanks to nanos, science and technology foresee a fascinating new world, infinite new research fields, and miraculous new possibilities.

From materials to energy, the environment to medicine, via electronics and agriculture... nanos should make everything more efficient, more resistant, cheaper and less polluting...

Nothing in our world will be free from nanos... a prospect which sometimes appears quite alarming...

Welcome to the Nanoworld.. to the Nanoworlds...

TITLE :

**WELCOME TO THE NANOWORLD**  
... NANOWORLDS AND MAXIFEARS ...

01 15

**HAROLD KROTO**

*My father taught me many lessons, that I realize now, ha ha, after he's dead! But, one of the important ones, was that when the atomic bomb test, I think in the 1955 he said, these things exist now and another Hitler will come along and use it. And, of course he was a refugee from Berlin, Um, my worry is that the area that I'm involved with Nano Technology or chemistry of the twenty first century will be skewed too much towards making these weapons more efficient and effective.that's certainly something that preys on my mind and many of my colleagues as well.*

01 55

**COMM 2D-3D Animation:**

It's the year 2015. The world is undergoing a terrifying catastrophe. It all starts in South Korea, with the explosion of a factory specialising in the manufacture of carbon nanotubes.

Tens of tons of toxic nanometric particles are ejected into the atmosphere, making the air unbreathable.

As soon as the catastrophe is announced, governments and experts alike declare that everything is under control, that the damage is limited, and there are no major risks.

But nobody really believes them. No-one is reassured...

On a fishing boat off the coast of Japan, the high concentration of nanoparticles contaminates the fish, making them unfit for consumption.

Reports soon confirm the scale of the disaster's effects, and its impact on the food chain, from the Arctic to the South Pacific.

In Europe, strikes and demonstrations grow in scale and number. No-one wants to work in the factories and installations making nanoparticles.

Workers and managers are scared, and claim reinforced security measures. And even a complete moratorium.

At first sanitary and ecological, the disaster becomes economic, on a global scale. The nanoparticles, produced industrially and now present in thousands of products, are massively rejected and boycotted by consumers. Whether they are potentially toxic or not.

The fear of being poisoned is widespread.

The word « nanotechnology » is now taboo.)

03 20

**COMM**

Science fiction, or a realistic future ? Such images, and such a nightmarish story are inspired by scenarios envisaged by the European Commission, with a view to being able to anticipate and react effectively to society's concerns.

Nanosciences and nanotechnologies allow us to work on the nano scale, which concerns just one billionth of a metre. They offer truly fantastic prospects. But because they manipulate matter atom by atom, they also generate real fears, inversely proportional to their size.

By their potential power and effectiveness, are nanotechnologies really dangerous ?

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**SYNTHE :**

BRUSSEL

03 50

**COMM**

This journey focuses on that very question, and we begin in Belgium, with Renzo Tomellini, director of the European Nanotechnologies initiative between 2003 and 2008. he comments on the catastrophe scenario...

04 03

**RENZO TOMELLINI**

*Europe immediately began discussions with the public and with anyone wishing to participate in the debate. Europe immediately launched research on a major scale to see the possible risks, not knowing if there were risks or not, but saying, as always, « we have to look into this subject ». These scenarios are useful, because they enable us to see what is lacking and therefore to take the necessary and appropriate measures.*

*Nanotechnologies are invisible ; they move and do things. Obviously, this has an effect on everyone's imagination.*

04 48

**COMM**

After a first phase of enthusiasm, in the past few years nanotechnologies have also given rise to doubts. The great economic, scientific and industrial powers have invested massively in this technology of the future... But after the scandal of asbestos, and the concerns over GMOs, they understand that the public's mistrust has to be anticipated and dealt with.

05 10

**COMM**

As Virilio said, when inventing the plane, we also invented the air crash.

Terrifying nightmares, or legitimate fears ?

Mihail Roco, who, since 2000, has embodied the United States commitment to nanoscience and technologies, is passing through France, visiting the Minatec research centre in Grenoble. I ask him about the principal fantasies engendered by the nano revolution...

Starting with the strange story of « grey goo »...

05 33

**MICHAEL ROCO**

*the media pick up that will have grey goo effect, they took information from several websites that uh estimated that few Nanobots form a few Nano molecules of few Nanometers will be able to multiply themselves to an infinite level and will transform the world how we know it .*

06 05

**COMM**

The basis of this nightmare was a thesis put forward by the controversial scientist, Eric Drexler, then a novel by the bestseller writer, Michael Crichton, « Prey ». This terrifying story concerns nanorobots, originally designed for espionage purposes, and which develop through self-assembly. Out of control, they multiply indefinitely, and the grey cloud they form becomes a veritable predator.

The plot uses the age-old theme of the sorcerer's apprentice... Science is blind to the power of its own discoveries...

But the book is effective...and fear of the nanoworld becomes a fashionable concern.

06 45

**MICHAEL ROCO**

*This was repeated in many websites, many people repeat it and disappear in 2003 because there is no facts to support this. Transhumanism is another trend going to a level of our assumption made without having any foundation.*

06 54

**COMM**

As well as the fear of a world destroyed by out-of-control technology, the other old fantasy, revived by nanos, concerns a new, improved human being, transformed by the power of science. A post homo sapiens.

William Bainbridge, a renowned American sociologist and member of the National Science Foundation, is one the promoters of such an idea, supported by a movement called Transhumanism.

07 15

**ARCHIVE**

**William BAINBRIDGE**

*"TRANSVISION" 2006*

*Helsinki University*

*I argue that transhumanism is really not a choice but a necessity. If we do not evolve we will devolve toward something subhuman rather than super human*

07 32

**COMM**

The movement was born in California in the late 1980s. It dreams of a future when man will finally be freed of his biological constraints and able to control his evolution thanks to technical progress.

07 45

**MICHAEL ROCO**

*Transhumanism is another trend going to the level of our assumptions made without having any foundation.*

07 54

**COMM**

And yet what fed such fears was the 2002 publication of a report co-signed by William Bainbridge and Mihail Roco himself.

It defended the idea of converging nano-technologies, bio-technologies, information technology and cognitive sciences to improve human performance.

But Mihail Roco claims he is not at all involved in this direction today. For him, apparently, it's not a serious option.

08 19

**MICHAEL ROCO**

*Transhuman is not part of the scientific trend, it's not part of technology, it doesn't have anything to do with this it's just a speculation made by different association in order to propagate their funding and their uh survival, it's nothing relating to our problem.*

08 43

**COMM**

This opinion is not necessarily shared by numerous scientists who gravitate around the Transhumanism movement. It is true that just about everyone would like to believe in the old Superman fantasy. The military dream about it... Improving man, his equipment, his tools, his weapons...

And perhaps, if we're examining real reasons to be afraid, we should check out such traditionally diabolical areas... The availability of explosives that are ten times more powerful, and ten times simpler to produce and use...

Nano-technologies have a potential for multiplying fire-power and introducing new weapons combining computers, chemistry and biology. I can envisage them radically transforming the battlefield. But it's not easy find the slightest piece of relevant information... tangible proof, perhaps, that something's going on... Everything is top secret...

**SYNTHE :**

BRUSSEL

**COMM**

The only military expert prepared to answer my questions is Alain de Neve, an analyst at Belgium's Royal Military Academy.

09 35

**ALAIN DE NEVE**

*Whenever we increase the resistance of our manpower material, the equilibrium of terror is completely disrupted. Which means that as a consequence, one of the actors or powers, fearing that another power is making advances in the domain of material resistance, and therefore fearing competition, could be inclined to want to further develop their offensive systems. These offensive systems could also be much more discreet, and therefore slip through the arms control systems that are currently being developed or which already exist.*

*The question is always about checking on what happens in the sidelines. The idea is even being put forward about creating an international nanotechnological agency to control the transfer of nanotechnologies to the military sector, just as there's an international atomic energy agency.*

**SYNTHE :**

SAN FRANCISCO

10 46

**COMM**

In the United States, the world's leading military power, one quarter of the funding for the National Nanotechnology Initiative is devoted to Defence concerns.

Consequently, the claims of Mark Bunger, a specialist in nano trends on the west coast, appears contradictory...

11 04

**MARK BUNGER**

*I really can't think of anything in Nanotechnology that gives a um a you know a much greater offensive weapon capability. We've already got nuclear arms, we've got uh uh, we've had um bio weapons for a long time, those are much much more potentially dangerous than anything that would come out of Nanotechnology, so Nanotechnology could help make the uh insurrection, you know those people would have better equipment, better armour, but again these are relatively mundane things, I don't think it's gonna help them get a new type of weapon that's on the order of a nuclear weapon. I could see some problems with the residue of some of these this equipment decades after the war is over, you could have Nano materials that would still be in the environment, that would still be a potential toxin.*

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**ALAIN DE NEVE**

*Unfortunately, current debate about nanotechnology quite flagrantly omits all the ethical and security-linked questions concerning their use or their potential uses.*

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**COMM**

If there's one country that likes a good debate, it's France.

**SYNTHE :**

PARIS

12 20

**COMM**

I meet Françoise Roure again : an economist at France's General Council of Information Technology, an organisation that depends on the Ministry of the Economy. She explains her point of view.

12 27

**FRANCOISE ROURE**

*Nanosciences and nanotechnologies, through the fantasy images of science fiction, seem to be the focus for all of humanity's age-old fears. And it happens to be the 21st century that is firing the collective imagination.*

12 44

**COMM**

The threat to our personal liberties is another concern attached to new technologies... Nanos could well increase the possibilities for surveillance and personal data recording. Some reports mention small chips, called RFID tags, or Radio Frequency Identification tags, as being one of the tools making spectacular progress in the field, with increased power and reduced costs.

13 08

**FRANCOISE ROURE**

*When we look at the new possibilities offered by nanoelectronics, we can see that this market could practically double with the development of RFID tags, with the development*

*of sensors and other objects that communicate through networks. And so, as of today, it would appear that the potential markets for information and communication technologies could well be multiplied by two... markets that are themselves based on the branches of electronic technologies based on the nanometric scale.*

13 41

### **COMM**

Certain RFID devices are already present, all around us, and even, for certain uses, « in us », in the form of labels and tags used for recognition at a distance. But they are still fairly primitive... They are cumbersome, expensive to implement and benefit from only a few simple functions.

The fear is that by using nanotechnology, the RFID devices could become commonplace. They could become much more effective, invisible, accessible and omnipresent... Everything would be tagged, and would « talk », communicating information about our lives. They could be transformed into a fantastic means of surveillance and control... Just imagine... one can imagine anything, and we often imagine the worst...

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### **COMM**

But ultimately, is this not just one of those recurrent fears, that are reactivated with every new technological breakthrough ?

This time, though, the situation is rather different. The awareness of the problems involved came immediately. Whether independent, or initiated by states themselves, the discussions and debates concerning the issues raised by nanosciences and nanotechnologies began at the same time as the technical developments were being made.

Calm or agitated, violent or petty, there's something for everyone... for every conscience and for every taste.

More constructively, protest groups in the south of France, with participants from every continent, meet in a 17th century hamlet transformed into a seminar centre.

### **SYNTHE :**

HAMEAU DE L'ETOILE

### **COMM**

Among those who say « no », is the Canadian activist Jim Thomas, who watches over the possible excesses linked to new technology. His position is clear, and well-rehearsed...

15 20

### **JIM THOMAS**

#### **COORDINATEUR NANOTECHNOLOGIES**

#### **ETC GROUP**

*Every time you have a path for a new technology, it's the powerful that use it first for their interests. And certainly it is not surprising that the military and the security states are finding applications for nano-technology and some of the threats, the weapons threats that come from nano-technology, the ability to create new bio-warfare agents from scratch or the ability to create new chemical weapons that can evade existing systems are very real. They are pretty much here already. And they will be used.*

*This sort of science that has brought us the technologies of the last two hundred years has always been very partial and has often turned out to be wrong. That a hundred and fifty*

*years after the introduction of synthetic chemicals, we're now dealing with the fallout of the toxicity effects, the impacts on our atmosphere, the impacts on our fertility, and that we need ... science in particular needs to be much more humble. That « nano-world », that « quantum world » and the science that follows from that is extremely interesting and ... but we need to divorce the science from the commercial application and manipulation of that science.*

*And definitely we should be concerned that there are hundreds of products in the market and yet we don't have regulation, we don't have toxicity testing, we don't even know how to develop the protocols for understanding the toxicity of these materials. That should be a wake-up call for taking those products out of the market, locking them up in a laboratory and then deciding as a society how we are going to mitigate against the dangerous impacts of this technology.*

16 58

**COMM**

But let's confront this militant viewpoint with the reality. Far removed from nanorobots, super-men and scientific fantasy, the practicalities today concern clothing containing nanoparticles, washing-machines, food... various applications already part of our daily lives.

**SYNTHE :**

MONTPELLIER

**COMM**

This is what Georgia Miller tells me. An Australian, from Tasmania, she's a member of the Friends of the Earth.

For the first time, someone explains to me the potential dangers linked to nanoparticles, and in particular, nanoparticles of silver, used for their antibacterial properties.

17 32

**JOURNALIST**

what are the main category of product in which you have you have concern I mean in in electromanager?

17 38

**GEORGIA MILLER**

*well, in these clothes washers and dish washers that we see around us here, they are now containing Nano particles as silver and that's a concern for us, partly because early studies suggest Nano particles of silver can be toxic to human cells and so for example there is a potential in a dish washer for there to be a residue of Nano silver which is left on the product. The other concern is for the environment because silver will leave the dishwashers and the clothes washers in the water stream and that could potentially interfere with good bacteria in in water systems, it could also potentially accumulate in recycled water to pose toxicity to our health*

18 26

**JOURNALIST**

Where does the danger begin with a fridge like that ?



18 29

**GEORGIA MILLER**

*Well for a fridge like this which may contain silver Nano particles em the danger actually begins before the fridge arrives here, when the workers are manufacturing a process, so for them it's the question of exposure in the workplace but also em the manufacturing process itself can be very em toxic, it can take a lot of energy and it can produce em by products of Nano particles and other substances which can in themselves be harmful. Em, but once we get this fridge into the home of the consumer. there's a lot of uncertainty about exactly how companies are using Nano particles in fridges like this, so for example where, where are the coatings? And we also don't know very much about the potential for migration, em so that means for Nano particles to come out of the coating they come onto our hands, and also about how these coatings will break down over time. And then of course, even after the consumer is done with the fridge, and the fridge goes to recycling or to land fill there's another question about waste **stream** so where will the Nano particles that are in the fridge go.*

19 43

**COMM**

What we do know, on the other hand, is that the specific characteristics of nanoparticles make them very different from normal molecules. Are they dangerous?

There is no definitive answer today. We are sadly lacking in sure-fire information concerning their real effects, even if we are sometimes using them to protect us.

In the cosmetics sector, for example, nanoparticles are used in the composition of several sun creams.

How should we view this?

20 05

**MARK BUNGER**

*There is a lot of use and uh Nano particular titanium dioxyde as a way to have you know sun block that ah is invisible, that doesn't leave a white paste on your face. Um that's something I would look at, you know the shape of those particles can really effect how they penetrate the skin ah you know how they get inI have three kids all under the age of eight and I don't think I would put some of these sun creams on their skin because the particles ah, we just don't know enough about what happens to them, either on the person or after they get washed off and go into the environment. So I would wait until we know more about whether and when they're harmful.*

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**COMM**

It's surprising. No-one agrees... For Mihail Roco, cosmetics cause no problems.

20 51

**MICHAEL ROCO**

*The skin is designed in eh historically to protect against penetration in a way or another, however, in the intestine basically is no protection, and so if you have a large amount of potentially harmful Nano particles, there is no way to stop this and so eh this is a real concern from scientific point of view. The concern is serious because people eh eat this, it's something that is a direct contact with their body and they are concerned about short and long term implications.*

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**COMM**

A warning of this nature, coming from someone who's supposed to be an unconditional nanosupporter, certainly gives food for thought. Particularly as many food products may already be using nanoparticles. « May » is the operative word, as it's impossible to know just from reading the labels. Industry has no obligation to provide that information. And more often than not, no obligation to subject their nanoparticles to safety tests.

21 49

**GEORGIA MILLER**

*We don't yet know how Nano foods for example will behave in our body, we don't know what the long term health harm will be because there's no long term safety studies being done at all, but what we do know is that the early test tube studies show us in some cases there can be quite serious new risk and we also know that because they behave so differently in smaller particle form we can't predict what that risk will be, so so that's why we're saying not all*

*Nano particles will poise new safety problems, but there's enough to know that some do and there's enough to know that we can't predict it from from what we know of the larger particles.*

22 43

**MARK BUNGER**

You take something that's you know a a large block of food ingredient and you break it down into particles that are micron sized or Nano sized, it doesn't matter because as soon as they get in your stomach, the enzymes in your stomach just break it up into molecules and atoms anyway and it has no effect whatsoever on how risky it is, how toxic it is or anything, it makes a difference on your tongue because your tongue can taste it differently, ah it might allow the food maker to use less of an expensive ingredient, but there's no, no risk involved in.

23 14

**COMM**

Once again, we have two conflicting views. Everyone passes the buck. Everything may be clear, but nothing is simple. Opinions differ, certainly... But who should we believe ? What should we think ? Confusion is widespread, and I'm rather lost...

23 25

**GEORGIA MILLER**

*To my knowledge, there is no studies that actually look at how nano-particles, that are added to food, actually behave when in the human body. There has been a few early phasing studies using mice, but they've used very high doses, so they are not realistic. Those studies that have used things like titanium dioxide and zinc which are now being used in nano-form of food, found that a high dose can produce quite severe organ damage and toxicity. But like I said it's an early study and it's a very high dose so, yeah, we really just don't know what it's going to be like in the human body.*

24 06

**COM**

How can we decide, in the absence of serious studies ? Why not consult those who are most likely to be in the know ? The toxicologists, who examine every product around us, be they inhaled, swallowed, or spread on our skin...

**SYNTHE :**  
**ZURICH**

24 17

**COMM**

I got to Switzerland to see one of the leading nanoparticle specialists : a Scotsman, Ken Donaldson, from Edinburgh University.

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**KEN DONALDSON**

*Toxicologists don't study risk we study what's called hazard so and it's a very def definite and uh profound difference between hazard and risk and many people do not understand the difference.*

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**COMM**

What's the difference between hazard and risk? One example... The great white shark is potentially very hazardous for man. But if I swim in a freshwater lake in Switzerland, there's no risk of meeting one, and of being eaten alive... The danger is therefore relative to the exposure to the threat...

24 52

**KEN DONALDSON**

*One of the problems is, it's very difficult to measure Nano particles, they're very small and there's not there may not be very many of them but they may be quite hazardous, so we still have not got the exposure measurement right that leads us to get to risk, so um that's very important, so and and and the number of studies where they've actually measured exposure to Nano particles is very low, so there are many people studying the hazard but few people studying the exposure, therefore there's hardly any data on risk.*

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**COMM**

Hmmm... It's not necessarily very clear... All I want to know is, is it toxic, or not ? But even by attending all the conferences on the subject, and listening to the experts, it's not easy forming a precise idea...

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**KEN DONALDSON**

*The real differences between Nano particles and uh traditional particles that cause disease uh is they seem to be able to move from the lung for instance where they breathe in to other places which was never the case before, in coal miners they get lung disease, they don't get any other kind of diseases really, whereas with with Nano particles if they can enter the blood they can pass through other organs they seem to be able to enter the brain, and and maybe able to cause problems there, the question is other man made Nano particles which will be, will they all be the same, will they be less, will they be more harmful um, we don't know and that's where we are, and that, and we're we're we're not very far because we're not very far into the Nanotechnology er era, um I think in ten years time we'll be much better placed to say yes they were just the same harmfulness as conventional diesel Nano particles which is the common one we're all exposed to, but we just aren't there yet, my feeling my personal feeling is that there will be many Nano particles which are less harmful or the same harmfulness as diesel soot, there will be some*

*which are a bit more harmful and a very few which are really harmful*

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**COMM**

So where does this take us ? Don't panic, or run for your life ? If everyone is being very cautious, it's perhaps for simple geometric reasons... as a thousand particles measuring 100 nanometres across have a surface area much greater than a particle of one micrometer, resulting in substantially more contact with the skin.

In addition, the rare toxicological data available is not even comparable, as it is not always expressed in the same units of measurement.

And yet Ken Donaldson tries to reassure me...

27 22

**KEN DONALDSON**

*There's certainly a number of Nano materials that are very low in toxicity and I don't think we need to worry about hardly at all, alumina, silica, titanium dioxide, carbon black, in general will be low toxicity, um Nanotubes, uh other kinds of Nano wires, any any Nano material in a long thin form, our data would suggest uh will will will behave like asbestos in as much as is the long harmful and the short not harmful, and we found that it was exactly like asbestos.*

27 55

**GEORGIA MILLER**

*I find it so infuriating that Carbon Nanotubes are now in commercial use in Australia, we don't know where, we don't know which places, manufacturers don't have to tell their workers, the unions don't know about it, no-one has to go through new safety testing, and yet we know that those Carbon Nanotubes could be linked to asbestos like disease down the track and we could face a repeat of this.*

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**COMM**

Thanks to Ken Donaldson's research, we know a little about the toxicity of nanotubes... the stars of the nanoworld, whose original properties could improve materials, electronics and even medicine... Potentially, some of them, the longer ones, are toxic... but does that mean they are dangerous ? We have to go back to our white shark analogy... To what extent are we exposed to these nanoparticles ?

28 40

**SYNTHE :**

LACQ

**COMM**

The question is partly answered in south-west France... In a company with a pilot production unit for carbon nanotubes...

28 46

**DANIEL BERNARD**

*Nice to see you...*

28 48

**COMM**

I am greeted by Daniel Bernard, a chemist...

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**DANIEL BERNARD**

*I used to be called the Lord of the Nanos...*

**COMM**

I thought I'd be visiting a hi-tech laboratory, but apparently not...

29 00

**DANIEL BERNARD**

*Here we have the pilot reactor for producing carbon nanotubes. These tubes are a few nanometres, or a few tens of nanometres in diameter, and a few micro-waves or tens of micro-waves long.*

*The nanotube comes out through this tube, to reach the packaging stage. We have developed a system of safety valves that prevent any nanotubes from being released outside.*

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**JOURNALIST**

*You're producing in an open environment ?*

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**DANIEL BERNARD**

*The whole process is not at all open, it's all closed, including the packaging. The nanotubes never see the atmosphere, and so the work space. People who are working here are absolutely not exposed.*

*So we'll take a reading, by the packaging system... and here we can see that there are between 12,000 and 13,000 nanoparticles per cubic centimetre, which is not very much for a normal atmosphere, because above the ring-road in Paris, you'll find concentrations of nanoparticles three or four times as high.*

30 16

**RENZO TOMELLINI**

*It's not realistic to think that every nanoparticle is safe, it's quite simply impossible. What should be done is that the products generated by nanotechnology should be made safe, that the manufacturing processes in the factories, and the intermediate stages should be safe, and that the product, for example the textiles you were talking about, should be safe when it's being used and at the end of its life.*

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**COMM**

Yes, that would, indeed, be better... And I'm also in favour of banishing hunger around the world, ending all wars, and for everyone to love each other...

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**JOURNALIST**

*Do you think we've learned from the mistake of the past? You were speaking about asbestos.*

31 04

**KEN DONALDSON**

*Yes, yeh, we won't have another another asbestos, but we have to be we still have to be careful and vigilant to make sure that doesn't happen, but it seems most unlikely that anything like that will happen.*

31 16

**FRANCOISE ROURE**

*We're fortunate, in terms of nanosciences and nanotechnologies, that we're in a period after the major problems linked to nuclear power, and after the major problems of GMOs. So, in a way, civil society is learning, as is, I would say, the international institutional environment and industry in general.*

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**COMM**

We're fortunate... If we've learnt anything, it's that we have to be wary. What do they think at the AFSSET, the French agency for sanitary safety in the environment and at work ? It has produced several reports on the impact of nano-materials. David Vernez acts as their spokesman...

31 57

**DAVID VERNEZ**

*I think it was about ten years ago, just as the first nano-materials were being developed, that scientists began to show signs of concern, and to underline the fact that an enormous amount of money had been spent on developing this technology, but comparatively very little on evaluating the risks involved. So this incited quite extensive mobilisation in the scientific world and among the public authorities.*

32 23

**JOURNALIST**

*What were your conclusions on the matter?*

32 27

**DAVID VERNEZ**

*One conclusion is a matter of principle, and that is to say that there is no certainty, toxicologically, first of all because it's too early ; we don't know the long-term effects... but at the same time, we're not going to wait until we do know the long-term effects before we act. And so we act on the exposure, and the idea is to say, let's apply the principle of precaution, and implement measures which will allow us control the levels of exposure, in order to reduce any risks that are subsequently defined. But I agree with you, we're not in an ideal situation, with the ideal situation being that the harmlessness can be demonstrated.*

33 04

**COMM**

It's a reassuring thought... The principle of precaution is appropriate... Its application even seems to have been anticipated by certain industries and laboratories... So everything is all right.

Except... in practice, this principle of precaution is just that... a principle. It's by no means a law, only an encouragement for prudence. Everyone can do what they like...

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**GEORGIA MILLER**

*What motivates me to continue working is em is not necessarily a belief that we can turn this whole thing around because I recognise that all of the Fortune Five Hundred companies and governments worldwide are investing many billions of dollars in this in a very community Nanotechnology commercialisationIV but if we can try to et some measures in place to stop repeating some of the dumb disasters that we've walked into with our yes opened before, I think that in itself will be very valuable.*

34 05

**COMM**

Knowing that we know nothing is not very reassuring. Especially when some people use the word nano just for marketing purposes.

One case in Germany made the news... A spray, « Magic Nano » was banned after several people were intoxicated. No to nanos ? Not at all... In reality, the spray had nothing nano about it, it was just claiming to be an innovative product.

So how can we know what's what, as consumers ? Ideally, we should be able to distinguish between what's real and what's fake. But clearly this is impossible today. And so it's not surprising that some people are getting paranoid...

34 37

**MARK BUNGER**

*Companies say « Well, if we give them too much information, we'll just scare them. That's the wrong approach. They should give them the information and people are smart. They'll figure it out. They'll get help understanding what they don't understand.*

34 50

**COMM**

We head for Switzerland again. I need some peace and quiet to take stock and regroup. Nanotechnologies arouse certain fears... Some are merely fantasies, but some particles, as always in chemistry, could well be toxic. But we're lacking the means to test them, and the time to be sure of the long-term consequences.

The fact is, that one needs to be exposed to them. But doubts subsist here too, as nanotechnological applications are present in numerous products, and there's no legislation requiring this to be mentioned.

The only thing I'm sure of, concerning these questions, is that the debate is legitimate. And even the toxicologists should be taking part...

**SYNTHE :**

**ZURICH**

35 28

**COMM**

In Zurich, Harald Krug is organising a congress, which begins with a little cruise...

35 38

**HARALD KRUG**

*We toxicologists are the poorest scientists in the world because we are always behind the others, first come the invention of let's say a new material or a new fact that can be used*

*then comes the production and after the production directly the use and then we the Toxicologists always behind, this is the reason why we have such a huge number of chemicals in the world and only less is investigated if they have any toxic effect.*

36 20

**KEN DONALDSON**

*You'd be surprised how many materials are um people are being exposed to that are not tested, you'd be surprised, many many chemicals are being used in industry and are not thoroughly tested*

36 24

**HARALD KRUG**

*So we are always behind of course, and we are much more behind if these activities are reduced and if we don't get any money any more, so on the European level as well as in some countries they have realised it just now the governmental level has realised it and they fund em more and more of these projects especially regarding the Nano materials.*

36 49

**COMM**

Well, that's good news. And it was time... Long live Europe... But what about the rest of the world ? If we're alone against everyone else, we're fighting a losing battle...

37 00

**MICHAEL ROCO**

*In US alone we have per year at this moment about seventy million with primary focus on environmental health and safety and worldwide it's about double, I think it's about hundred and twenty million for environmental health and safety in two thousand and seven, two thousand and eight eh annual eh expenditure.*

37 25

**COMM**

It doesn't seem enormous. And the figures are hard to verify. According to some sources, it could be double that. When we look closer, it's clear that less than 3% of expenditure in the nanotechnology field is devoted to studying the risks involved. But then this is a fairly standard proportion in scientific research...

37 43

**FRANCOISE ROURE**

*Investments in terms of knowledge, or identifying the risks in terms of toxicity or ecotoxicity are not sufficient, this has to be said quite clearly. These expenses are not an option, they absolutely have to be made in order to make the whole process safe and they should probably also be shared between the public and the private sectors.*

*If we are able, on an international and institutional level, to agree among ourselves, first of all about the priority of establishing a cartography of the risks, and if we are also capable of recognising that there are more advantages than inconveniences in sharing the knowledge of these risks... systemic risks, ecological risks, risks of toxicity for the human body and living beings, as well as social risks, systemic social risks... then at that point, we can create a context where regulations have a chance of evolving in a synchronised manner, and at best, not in a divergent manner.*



38 42

**COMM**

So basically, everyone has a chance to agree... that's the simple version in non-diplomatic language.

The stakes are certainly high if we don't want to waste the wonderful opportunities that nanoscience and nanotechnology promise, including the prospects of a new society.

But on this question, Jim Thomas is not « at best, not divergent »... he doesn't believe it for a second...

39 11

**JIM THOMAS**

*Every time you have a path with these new technologies, you have a promise that maybe this is going to let you leap some of the inequalities that exist in society. And in fact what we see is that you have an unjust society, new technologies tend to exacerbate those injustices and those inequalities. Although there are some southern countries, developing countries, Brazil, India, China, who are trying to put a lot of money into nanotech to try to keep up with the nano-race that is developing, for the majority of poor countries who don't even have the benefits of some of the existing technologies that we enjoy here in the west, the idea that they are going to get on top of the nano-technology revolution and apply it for their people, is a pie in the sky, it's fantasy.*

40 00

**COMM**

Such promise on one hand, and such pessimism on the other...

Could nanotechnologies open up glorious new horizons for the emerging countries ? We head for South Africa to ask those directly concerned. Thembela Hillie is the assistant director of the nanotechnology department at the national research centre in Pretoria. He takes me to see a real-life project.

**SYNTHE :**

**MADIBOGO**

40 23

**COMM**

At a school in the bush, a pilot water treatment scheme is being implemented by Mbhuti Hlope from Mafeking University. The pump is equipped with a nanomembrane for filtering the water and making it drinkable, but without removing the beneficial minerals.

The school head is very proud of it...

40 38

**JOURNALIST**

*Ah, very salted ya*

**MAN**

*This one is the one which is purify. You can see the difference of color*

**JOURNALIST**

Yeh

**MAN**

*They are from the same reservoir. The color is different, I hope you didn't ...*

40 54

**JOURNALIST**

This one is not salted at all

**MAN**

*Is no salt in there.*

40 59

**JOURNALIST**

*So I should not have to drink this one*

**MAN**

*No, it's for cleaning and washing and other things. It was just for tasting.*

41 08

**MBHUTI HLOPHE**

*In South Africa in particular, nano-technologies is still very relatively new technology because, particularly in the water sector, we meet these municipalities and then we suggest to them that this problem can be solved by using nano-membranes. And then they do not act on this simply because they still are not familiar with this technology. So we still have really to do some XXX technologies...*

41 45

**THEMBELA HILLIE**

*I think that you can do nano-scale science and nano-technology is crucial. That those are developed should learn to partner with developing world because we understand our own problems and priorities. Now the partnership therefore could help for even adapting their technologies and also understanding the risk and the opportunities better. A lot has been happening in here of actually taking technology and putting, dumping it in the developing world. What happened is that if you leave the technology, it won't work, because people don't understand it. But partnership will make this technology sustainable and it can also give opportunity to the developed world about the market they can start to exploit because of those partnerships.*

42 35

**RENZO TOMELLINI**

*One chapter of the European strategy on nanotechnologies talks about international cooperation and the commission proposes that Europe works with both industrialised countries and less industrialised countries, so that we can attempt to avoid the creation of a nanotechnological gap.*

42 56

**JIM THOMAS**

*The problems that we are facing at root, problems of social injustice, the economic problems, these aren't things that can be solved with a technological band-aid, particularly with a high-tech nano-tech band-aid. We need to step back and not head down a destructive path.*

43 14

**GEORGIA MILLER**

*When we step back and when we ask what direction is Nanotechnology and food taking us,*

*we see that it's taking us to a future which is about larger scale agriculture which is more reliant on chemical inputs and technologies controlled by a small number of companies it's taking us to a future in which food travels further around the globe and stays longer on supermarket shelves before we eat it and to a future in which we eat more highly processed food, where the nutritional deficiency is sort of made up by Nano additives and so on balance we don't think that that's the sort of future that we want.*

43 51

**JIM THOMAS**

*For certain, with the nano-technologies we are seeing are an attempt to own nature at a very fundamental level. With biotechnology, we saw claims on genes, on this sort of basic units of life, but now the claims are going down to atoms and in fact even down to the elements of the periodic table and this is definitely, as much as it's an attempt to rebuild the world from atom upwards it is also attempt to own the world from the atom upwards, legally, through patents.*

44 34

**HARALD KRUG**

*you never get a technology without any risk, this is not possible, since we invented fire we have a risk, so Nanotechnology per say will have some risks but we have to decide if the balance between the risk and the benefit is on the side of the benefit*

44 54

**MARK BUNGER**

*We had a client that makes agricultural chemicals and so pesticides and things like that and the way to describe that process today as he told me was you find out how much you need to kill a bug, you multiply by ten and that's what you put on the plant. They had actually were filing for a patent on was a way to encapsulate those active molecules so that the bugs would eat more of them and be killed by those pesticides without having all this indiscriminate use of the pesticide all over the place.*

45 28

**GEORGIA MILLER**

*The argument here about benefit is that it will make them more efficient so that we can use less. Our concern is that, because they are more potent, these chemicals might produce new toxic problems.*

45 52

**KEN DONALDSON**

*No I'm I'm not for a moratorium I really think that we have to bear in mind that uh Nano particles are part of our every day life, your lungs are full of Nano particles, my lungs are full of Nano particles, if they go to the brain our brains are full of them, walk up through any city, I live in Edinburgh, you go anywhere in the world, you're exposed with every breath to millions of Nano particles.*

46 10

**COMM**

Risks and benefits... On this question, and to conclude our exploratory tour, one of the stars of contemporary chemistry sheds a little light.

And so we make a detour to Asia, for a final comment from a Nobel winner.

Sir Harold Kroto discovered Fullerene, the football shaped carbon molecules that are now

part of nanoscience history.

46 37

**HAROLD KROTO**

*We have to recognize that every powerful technology can be used and mis-used. If we go back a hundred years, we might be able to predict Bill Powl, terrible tragedy, we might be able to predict nerve gases, disgraceful application of chemistry which you... so we're going to sit down... ok, we're not going to do any chemistry from now on, from 1908 on, right ? We wouldn't have anything in this room. There's the wood that would be there. There would be no lacquers, no cameras, there would be no transistors, no computers, there would be no mobile phones, no penicillin ! The question that society has to confront is "Should we not do this or should we take the risk because the probable spin-off of society is so great and has been for chemistry.."*

47 27

**JIM THOMAS**

*People have a right to discuss. And to not discuss with a sort of gun to their head saying "This is happening anyway." Like a moratorium on the commercialization of this technology. We want to make sure that any products, any uses of this technology are safe, are suitable for, for people ..*

47 48

**MICHAEL ROCO**

*We need to have a precautionary approach, but not stop developing technologies and understanding the field.*

47 56

**FRANCOISE ROURE**

*I believe it would not be ethical to block all research in these domains just because the risks concerning one nanoparticle, one precise risk, one particular environment, have not been the subject of any research.*

48 09

**HARALD KRUG**

*If you have a moratorium and wait until the toxicologists come to an end, to a final decision, you missed the benefits in between. So, the industry will not produce, if they don't produce, they have no money for research, so the research on the applications will not going on, so you miss the benefits. And even the benefits on, as I mentioned, on the sector of energy, environmental solutions. So it's always the same, you have to decide going on to have the benefits and have a little bit of risk, a calculable risk, this is of course, you have to calculate it, then you can make this decision.*

48 55

**GEORGIA MILLER**

*What motivates me to continue working is... is not necessarily the belief that we can turn this whole thing around because I recognize that all of the Fortune 500 companies and governments world-wide are investing many billions of dollars in this and in nanotechnology commercialization. But if we can try to get some measures in place to stop repeating some the dumb disasters that we've walked into, with our eyes, open before, I think that itself would be very valuable.*

49 32

**COMM**

Should extreme precautions be taken as a defence in a debate among people on totally different wavelengths ? Who is right, and who is wrong ? Who knows enough about the subject ? The only conclusion is that it's very hard to decide when there are so many misunderstandings.

We therefore have to depend on society at large. Perhaps, this time, we will manage to avoid a new health and safety drama. Perhaps official standpoints will soon be less confused, and less compromised between the desire to act correctly, and deference to market pressures. Perhaps too, the wonders of the nanoworld, like the fears they provoke, will ultimately, in the future, be regarded as trivial...

And perhaps, we can hope and trust that, for once, society everywhere will progress as rapidly as its discoveries...

**TC OUT 50'18**

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