



NANOYOU film TRANSCRIPT

PART 1: WHAT IS NANO?

NARRATOR: What is nano

A man's beard grows 5nm every second; suffice it to say a nanometer is very, very small.

Despite its size you can see the effects of things happening at the nanoscale all around you. They give the sunset its red colour, allow birds to navigate and help geckos stick to trees. But it's only recently that we've actually been able to see down to the nanoscale.

This is NANOYOU

We humans are strange creatures aren't we if we're honest, we like to measure things.

Earth's tallest mountains are over 8,000m tall

A football pitch is around 100m. I myself am about 2M when I'm standing up, in shoes. Good afternoon.

Ants are a few mm long.

Skin cells about 30 micrometers.

We can't see things this small.

A bacterium is about 2 micrometers, smaller still are viruses and phages and so we go down to DNA, our molecular blueprints.

DNA is 2 billionths of a meter in diameter, or more conveniently, 2 nanometers. The units we use down here to measure the building blocks of everything. Welcome, to the nanoscale.

To explore the nanoscale we use very powerful machines called electron microscopes.

DR. JAMES BENDALL: Today we're going to look at two things that you may have seen before – we're going to look at a fly and a coin.



So this is the z on the coin.

This is the fly's wing and who'd have thought it would have all these little hairs sticking out from it. The tip of each of these hairs is only about 600 or 700 nanometers in diameter.

NARRATOR: When we use electron microscopes we explore new and alien landscapes. It's a strange new world down there.

The nanoworld isn't just unusual looking, things behave differently there too. One reason for this is surface area.

If you take a cube and lay the surface flat, you can see how much of that cube can react with the outside world. If you divide the same cube into 8 little cubes the surface area is twice as big. If you keep making smaller cubes the surface area becomes immense. More surface means more area for reactions.

This is why powdered sugar dissolves faster than sugar cubes.

Big lumps of aluminium are not very reactive but nanoparticles of aluminium are so reactive that they can be used in rocket fuel.

MIKE MORLEY: Another way you can show this is with flour, because flour doesn't burn very easily in a pile because it hasn't got enough surface area, but if you mix it with a lot of air then something quite different happens.

NARRATOR: Light also behaves differently as you head down to the nanoscale. White light contains all colours. When particles get really small they start to bounce only certain colours back, so you see them as those colours. As gold gets really small it stops looking gold and reflects red, purple, blue and finally becomes invisible when it's too small to reflect any colours of light that you can see.

These strange properties of light can be very useful.



PART 2: NATURE'S NANO

NARRATOR: Welcome to Nature's Nano

MATHIAS KOLLE: I've always wondered how butterflies and beetles can make these strong and iridescent colours.

So if we take a butterfly wing and put it in a microscope we see thousands and thousands of bright blue tiny scales. Each of these scales each of these scales is covered in tiny ridges running across each scale.

Each of these tiny ridges if you cut right through them look like a Christmas tree.

NARRATOR: This structure is finely tuned to reflect only the blue part of light so the butterfly appears bright blue.

MATHIAS KOLLE: If we just replace the air in this nanostructure with a bit of liquid you'll see that it changes colour from bright blue to bright green.

NARRATOR: It fills in the gaps around the nanostructure and makes it better at reflecting green light. When the liquid evaporates it returns to reflecting blue. Please, don't squirt butterflies

Life has spent over 3.8 billion years finding clever ways to use the nano scale. Now we can understand nature's nano secrets, we can use them for ourselves.

Many tropical plants have leaves where water just runs off, this keeps them clean. If we look at the nano scale we can see tiny structures which stop the water from sticking. By copying these structures we can make our own water repellent surfaces. Some that even honey doesn't stick to.

ULRIKE BAUER: Ants have really cool feet, they can stick upside down to surfaces holding up to 100 times their own weight without falling down. If we look closely we see tiny little pads on their feet which help them to stick.



NARRATOR: By investigating the microstructure of insects feet we can design surfaces hard for them to climb. Bad luck for cockroaches.

Pitcher plants eat insects that slip into them but they don't work unless all of their rim is covered in water. To make sure they're as slippery as possible they have a nano-trick up their sleeves.

ULRIKE BAUER: We can see how the water spreads, even upwards against the gravity.

If we look at them we can see they have lots of grooves running across their rim, and in between these grooves if we look on the nanoscale there are even smaller grooves.

NARRATOR: This is called a super hydrophilic surface which means that the surface likes the water and pulls it across itself. Once the water is spread thinly across these micro and nano grooves they become very slippery and it's goodbye ants, hello pitcher plant dinner.

Hydrophilic surfaces have lots of uses, but one particularly excellent one is in a new water filter. This can filter even the tiniest bugs from dirty water making it safe to drink.

Even really dirty water.

Looking around the natural world is a great way to think of things to make ourselves but with nanotechnology we can make new structures that nature has never even tried.



PART 3: MAKING NEW NANO

NARRATOR: Down at the nano-scale things are gloopy and there's lots of friction. This means particles stick together really easily and if this happens again and again new and complicated structures could be formed. This is called self-organisation.

Scientists have been carefully experimenting with different conditions to see what sorts of new nano structures they can create. The results are astonishing.

DR. JAMES BENDALL: Here are samples that I made under various conditions but when we zoom in on the nanoscale we can see that they are extremely different.

These one remind me of the Eiffel tower.

They're really quite beautiful these hexagons all stacked on top of each other like pyramids.

We can also make other materials such as really thin wires, ones that look like pancakes or ones that look like flowers.

NARRATOR: All these new structures have different properties. Soon they'll be changing the way we live, from solar panels that we spray onto our roofs to making computers and batteries so small that they're invisible.

The materials we use have some severe limitations. If you push things too far they break.

But nano-researchers are finding ways around these limitations.

DR INGRID GRAZ: Electronics is made out of silicon and silicon is not very stretchy. Wow! But we found a way to make electronics stretchy.

When you put a really thin layer of gold onto rubber and you stretch the rubber we found that the gold doesn't break.

NARRATOR: This is because when gold is just a few nanometers thin it forms cracks, and these cracks actually allow gold to stretch.



DR INGRID GRAZ: That means that in future you can take your mobile phone, stretch it, wrap it around your wrist or even embed it in your clothes.

NARRATOR: Using the new materials made possible by nanotechnology we could build stronger houses, tougher cars, and even make ourselves healthier.

Medical researchers are already looking at using nano-particles to deliver drugs or to hunt down cancerous tumours.

MR STEPHEN PRICE: I'm a brain surgeon it's my job to treat patients with brain tumours. What we would love is some sort of nano-particle that gets taken up by the tumours that allows us to identify where these tumours actually are.

NARRATOR: In the future nano-medicines could control your body, hunting down diseases and zapping problems.



PART 4: NANO CLOSE UP

NARRATOR: Standby for the smallest thing you've ever seen.

This might look like a deep-sea submarine but it's actually a scanning tunnelling microscope. Inside it's more empty than space and it has revolutionised our view of the nano-world.

DR COLM DURKAN: This is an image of a piece of carbon, and these spots are single atoms on a piece of carbon.

So one of the spots is one atom.

So this is the smallest thing that you can see, and it's the smallest thing that you will ever be able to see with any microscope.

NARRATOR: If you listen carefully you can even hear the atoms as the microscope scans over them.

This year, researchers imaged the internal structure of a single molecule for the first time. This is the most detailed view of matter that we've ever had. Remarkably it looks almost identical to our models.

DR COLM DURKAN: Not only can the microscope take images, it can also move things around. We can actually change the position of atoms one at a time using this microscope. So we can use the microscope to choose an atom on a surface, move it to a new place and then do this with as many atoms as we want to build up a new structure. And that's where nanotechnology comes in, because nanotechnology is all about changing the properties of matter atom by atom and making new structures.

NARRATOR: Throughout history we've been making smaller and smaller machines. Now scientists are looking at ways to create machines at the smallest scale possible, using atoms as their building blocks. Some researchers believe that we could construct molecular machines that could make anything we wanted. If this happens it will revolutionise our lives.

We know that molecular machines can work because they're in every cell of our bodies. They're working away right now turning food into



energy, fixing damage, keeping you warm and making new cells. You are already a masterpiece of molecular nanotechnology.



PART 5: THE NANO FUTURE

NARRATOR: Mark Welland is Professor of Nanotechnology at the Nanoscience Centre at the University of Cambridge.

PROFESSOR MARK WELLAND: Imagine a small implant which you can think of as being equivalent to your mobile phone that communicates directly with your brain, as the internet does currently, with the rest of the world. If I want to think a connection with my son who's walking in the Himalayas, I can think the connection and just as your mobile phone it would dial up the device inside my son and I would talk to him, I would see him, I would feel his emotions. We would be infinitely connected to each other and infinitely connected to all the information that's around us.

NARRATOR: If this all sounds like science fiction to you, think how quickly our world is already changing. Someone born in 1930 would never have believed that in their lifetime thousands of people would be flying around the world in metal tubes every day, that men could have walked on the moon and that you would be able to watch this film on something called the internet.

I hope that this has given you a taste of a world that has always been around but that we are only just starting to explore. Many people think that the coming age will be the age of nano, if so you will be the people to explore it and what your generation discovers will be perhaps the biggest technological leap in history.

It could take you into atoms and beyond the stars. Good luck!