OPM GROUP

Understanding public perceptions of specific applications of nanotechnologies

Supplementary appendices

Department for Environment, Food and Rural Affairs (Defra)

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Contents

Appendix A: Nanotechnology Glossary

Info	Definition
Allergen	• Something that causes irritation or an allergic reaction in someone.
Contaminants	• Something that makes a place or a substance (like water, air, or food) dirty or harmful.
Contamination	• To make something dirty or harmful by adding dangerous or undesirable things to it.
Digestive system	• The set of organs in your body that break down and process the food you eat.
Ecosystem	• Everything that exists in a particular environment
Efficiency	• The ability to do something or produce something without wasting materials, time, or energy
Emissions	• The act of producing or sending out something (such as energy or gas) from a source • Something sent out or given off
End of life (of a product)	• Used to indicate when a product is in the end of its useful life (from the vendor's point of view), and when a vendor intends to stop marketing, selling, or sustaining it.
Exhaust	• The mixture of gases produced by an engine • A pipe or system of pipes through which exhaust is released
Fuel economy	• The fuel efficiency relationship between the distance travelled and the amount of fuel consumed by the vehicle.
Ingest	• To take (something, such as food) into your body
Inhale	• To breathe in
Insoluble	• Not able to be dissolved in a liquid
Irritant	• Something that causes irritation
Membrane barriers	• A thin, bendable layer of tissue covering surfaces or separating or connecting regions, structures, or organs of a living organism.
Mineral	• A chemical substance (such as iron or zinc) that occurs naturally in certain foods and is important for good health
Moratorium	• A time when a particular activity is not allowed

Nanomaterials	• Any materials in which at least one of its dimensions is on the nanoscale • Many materials are used at their nanoscale because of the new properties they display or the ways that their small size allows them to be used
Nanometers	• One billionth of a metre
Nanoparticles	• A single unit of material that is on a scale below 100 Nanometers. • Nanoparticles can occur naturally or be engineered
Nanoscale	• The world when you look at it on the level of atoms and molecules. The nanoscale is the dimensional range of approximately 1 to 100 nanometres
Nanotechnologies	• Used in report to refer to various applications/products using nanotechnology
Nanotechnology	• Used in report to refer to scientific, technological phenomenon. Broad category (encompassing different forms like nanomaterials, nanoparticles, etc.)
Neutralise	• To stop (someone or something) from being effective or harmful • To cause (a chemical) to be neither an acid nor a base
Pollutants	• A substance that makes land, water, air, etc., dirty and not safe or suitable to use
Remediation	• The action of remedying something, in particular reversing or stopping environmental damage
Respiratory tract (also called the respiratory system)	• The passage formed by the mouth, nose, throat, and lungs, through which air passes during breathing
Substance	• A material of a particular kind
Surface area	• The total amount of outside area on the outside of something
Ultraviolet (UV) light (radiation)	• Is an electromagnetic radiation with a small wavelength (shorter than visible light but longer than X-rays)
Volume	• An amount of something
Wavelength	• The distance from one wave of energy to another as it is traveling from one point to another point

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Sunscreen

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Appendix C: List of stakeholders and project management team

Stakeholder workshop attendees

Name	Organisation
Darren Budd	BASF plc, BTC UK
Robert Lee	Birmingham University
Denis Koltsov	BREC Solutions Ltd
Jim Palmer	British Adhesives & Sealants Assoc. (BASA)
Paul Jackson	British Aerosol Manufactures Assoc.(BAMA)
Trevor Fielding	British Coatings Federation (BCF)
Alex Price	British Standards Institute
Roger Pullin	Chemical Industries Association (CIA)
Chris Flower	Cosmetic, Toiletry & Perfume Assoc. (CTPA)
Nicole Grobert	Department of Materials (Oxford University)
Jon Graves	Dept. for Health (DH)
Andrej Kobe	DG Environment
Erica Poot	DG Research & Innovation
Gary Hutchison	Edinburgh Napier University, Centre for Nano Safety
Donald Bruce	EdinEthics
Terry Woolmer	Engineering Employers' Fed. (EEF; manufacturers assoc.)
Trevor Howard	Environment Agency (EA)
Steve Dungey	Environment Agency (EA)
Richard Hawkins	Environment Agency (EA)
Vicki Stone	Environmental scientist (Heriot-Watt Uni, Edinburgh)
Keneth Chinyama	Food & Drink Federation (FDF)
Quasim Chaudhry	Food & Environment Research Agency
Barry Park	GBP Consulting
Stephen Holgate	Hazardous Substances Advisory Committee (HSAC; chair)
Nick Boley	Laboratory of the Government Chemist (LGC)
Judith Natanail	Land Quality Management Ltd.
Peter Dobson	Material scientist (Oxford University)
Hilary Sutcliffe	MATTER
John Wilkinson	Medicines and Healthcare Products Regulatory Agency
Pieter van Broekhuizen	Nanotechnology and Chemical Risks. IVAM UvA, Amsterdam
Steffi Friedrichs	Nanotechnology Industries Association, Brussels (Director General)
Charles Clifford	National Physical Laboratory
Rachel Smith	Public Health England (PHE)
Ellie Gilvin	Quantum Technologies, Engineering & Physical Sciences Research Council (EPSRC)

Alec Reader	SME- Nano Knowledge Transfer Network (KTN)
Lien Ngo	Technologists –Advanced Materials (InnovateUK, Research Council UK)
Stuart Challenor	Tesco
Sunita Gordon	University World News. (Previous EU projects NANoTECHNOLOGY & and NANoOPINION)
Martin McVay	Welsh Government

Stakeholders interviewed

Name	Organisation
Robert Lee	Birmingham University
Trevor Fielding and Wayne Smith	British Coatings Federation (BCF)
Steven Holgate	Clinical Professor of Immunopharmacology
Vicki Stone	Environmental scientist (Heriot-Watt Uni, Edinburgh)
Steffi Friedrichs	Nanotechnology Industries Association, Brussels (Director General)
Anna Gergely	Steptoe
Peter Melchett	The Soil Association
Sue Davies	Which?

Additional stakeholder input into stimulus materials

Name	Organisation	Area of Input
Amanda Isom	Cosmetic, Toiletry & Perfumery Association	Contributed to the sunscreen application materials
Chris Flower	Cosmetic, Toiletry & Perfumery Association	Contributed to the sunscreen application materials
Barry Park	GBP Consulting	Contributed to the sunscreen application materials
Vicki Stone	Environmental scientist (Heriot-Watt Uni, Edinburgh)	Contributed to the sunscreen application materials
Peter Melchett	The Soil Association	Contributed to the sunscreen application materials
Steve Morgan	Defra	Contributed to the contaminated land remediation application materials
Steve Morris	Defra	Contributed to the contaminated land remediation application

		materials
Trevor Howard	Environment Agency (EA)	Contributed to the contaminated land remediation application materials
Brain Bone	Independent Consultant	Contributed to the contaminated land remediation application materials
Peter Melchett	The Soil Association	Contributed to the contaminated land remediation application materials
Peter Dobson	Material scientist (Oxford University)	Contributed to the contaminated land remediation application materials
Barry Park	GBP Consulting	Contributed to the fuel additives application materials
David Santillo	Greenpeace	Contributed to the fuel additives application materials
Rachel Smith	Public Health England (PHE)	Contributed to the fuel additives application materials
Robert Walker	The Society of Motor Manufacturers and Traders Limited	Contributed to the fuel additives application materials
Peter Dobson	Material scientist (Oxford University)	Contributed to the fuel additives application materials
Trevor Fielding	British Coatings Federation	Contributed to the paints and coatings application materials
Wayne Smith	British Coatings Federation	Contributed to the paints and coatings application materials
Vicki Stone	Environmental scientist (Heriot-Watt Uni, Edinburgh)	Contributed to the paints and coatings application materials

Project management team

Name	Organisation
Steve Morris	Dept. for Environ. Food & Rural Affairs
Steve Morgan	Dept. for Environ. Food & Rural Affairs
Ian Sutherland	Dept. for Environ. Food & Rural Affairs
Kieron Stanley	Dept. for Environ. Food & Rural Affairs

Richard Vincent	Dept. for Environ. Food & Rural Affairs
Emma Stuart	Dept. for Environ. Food & Rural Affairs
Diane Beddoes	Office for Public Management
Caitilin McMillan	Office for Public Management
Bethan Peach	Office for Public Management
Zoey Litchfield	Office for Public Management
Morgan Wild	Office for Public Management
Michael Gentry	Office for Public Management
Daniel Start	Sciencewise
Anna MacGillivray	URSUS Consulting (evaluator)

Appendix D: Summary Agenda

1.1. Public workshop summary agendas

Date: Saturday 28th February

Timing	Activity
10.00 – 10.10	Introduction and welcomes
10.10 – 10.40	Getting to know each other
10.40 – 11.10	What comes to mind when you think of technology and society?
11.10 – 11.35	Tea break
11.35 – 12.40	Introducing and discussing new technology
12.40 – 12.50	Looking forward to the next session
12.50 – 13.00	Evaluation: what do you think of it so far?

Date: Saturday 14th March

Timing	Activity
10.00 – 10.20	Welcome back – And a bit of a recap on what we're all doing here…
10.20 – 10.45	What did we do last time we met?
10.45 – 11.00	Morning tea break
11.00 – 12.30	Looking at the four products
12.30 – 13.15	Lunch
13.15 – 14.50	Thinking more about the four products
14.50 – 15.00	Afternoon tea break
15.00 – 15.30	Ask the scientists
15.30 – 15.50	Our journey so far…and where are we going next?
15.50 – 16.00	Evaluation – how's it going so far?

Date: Saturday 28th March

Timing	Activity
10.00 – 10.25	Welcome back – and a bit of a recap on what we're all doing here
10.25 – 10.45	What comes to mind when you think about society and the nanotechnology products we've been looking at?
10.45 – 11.00	Intro to regulation and nano
11.00 – 11.45	Carousel to explore regulation, governance and the world outside…
11.45 – 12.00	Tea break

12.00 – 13.00	Carousel continued…
13.00 – 13.45	Lunch
13.45 – 14.15	Reverse Q&A
14.15 – 15.20	What's important when it comes to communicating about nano…
15.20 – 16.00	Reflections & Evaluation

1.2. Public Workshop materials

The materials developed for each public workshop included:

Workshop one:

- Introduction presentation to nanotechnology.
- Timeline of the use, discovery and development of nanotechnology (Appendix K).
- 'How small is small' wall chart examples to illustrate nanoscale (Appendix L).
- Nanotechnology FAQ boards and a more detailed version available for workshop facilitators.

Workshop two:

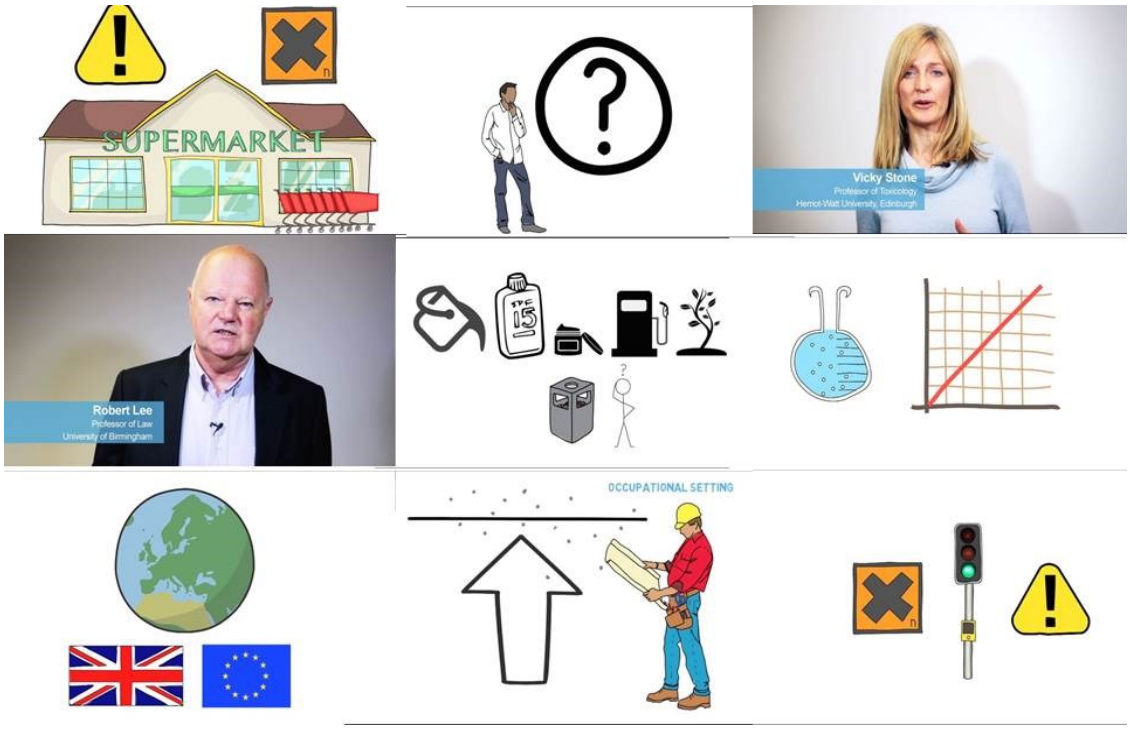
- 'Where can you find nano?' wall chart summarising the 12 nanotechnologies, with examples of how nanomaterials is used in the application, what the nanomaterial looks like, and what properties it generates (Appendix J).
- Overview posters to introduce our chosen specific nanotechnology applications: Sunscreen, Environmental Remediation, Paints and Coatings, and Fuel Additives. These posters covered the context of the application (including what is currently used and alternatives to nanotechnology); what type of nanotechnology is most used in this context; if there are benefits to using nanotechnology in this context; and if there are risks/concerns to using nanotechnology in this context (Appendix E).
- Product lifecycles for our four chosen applications (Appendix G).
- Case studies/scenarios on our four chosen applications (Appendix H).
- Learning discovery sheets for participants to note key points that resonate with them and questions (Appendix F).

Workshop three:

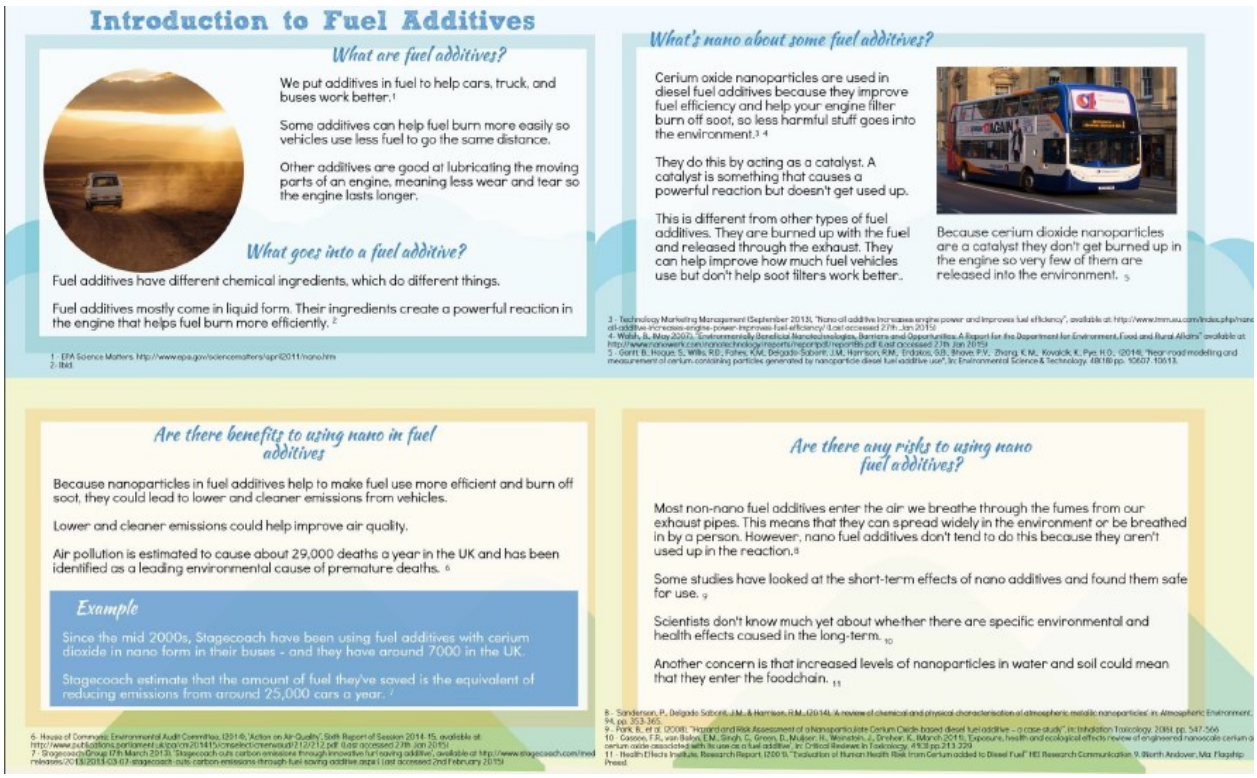
- Venn diagram for mapping perceptions of risk and responsibility for each application.
- Cards on potential risks of applications based on participant concerns voiced in previous workshops, and used alongside the Venn diagram material above (Appendix I).

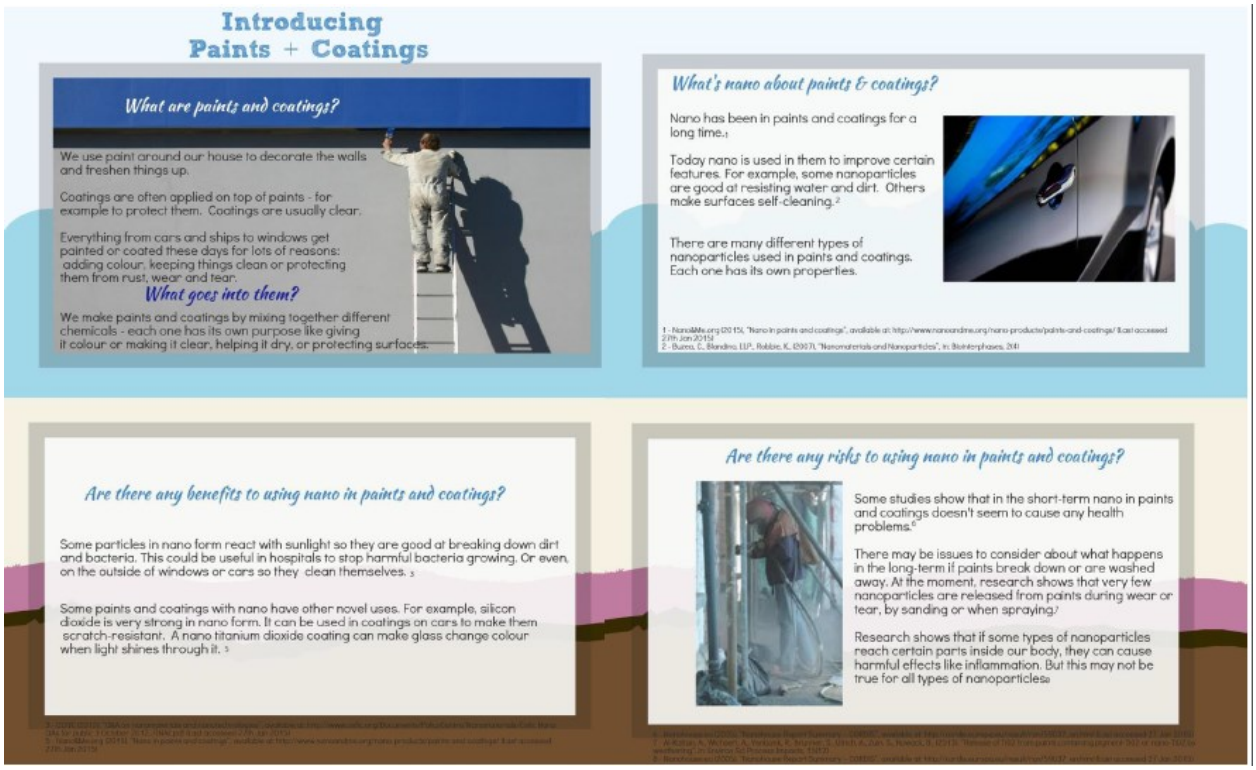
Figure 1.1: Example of Talking Head videos: introducing the debates

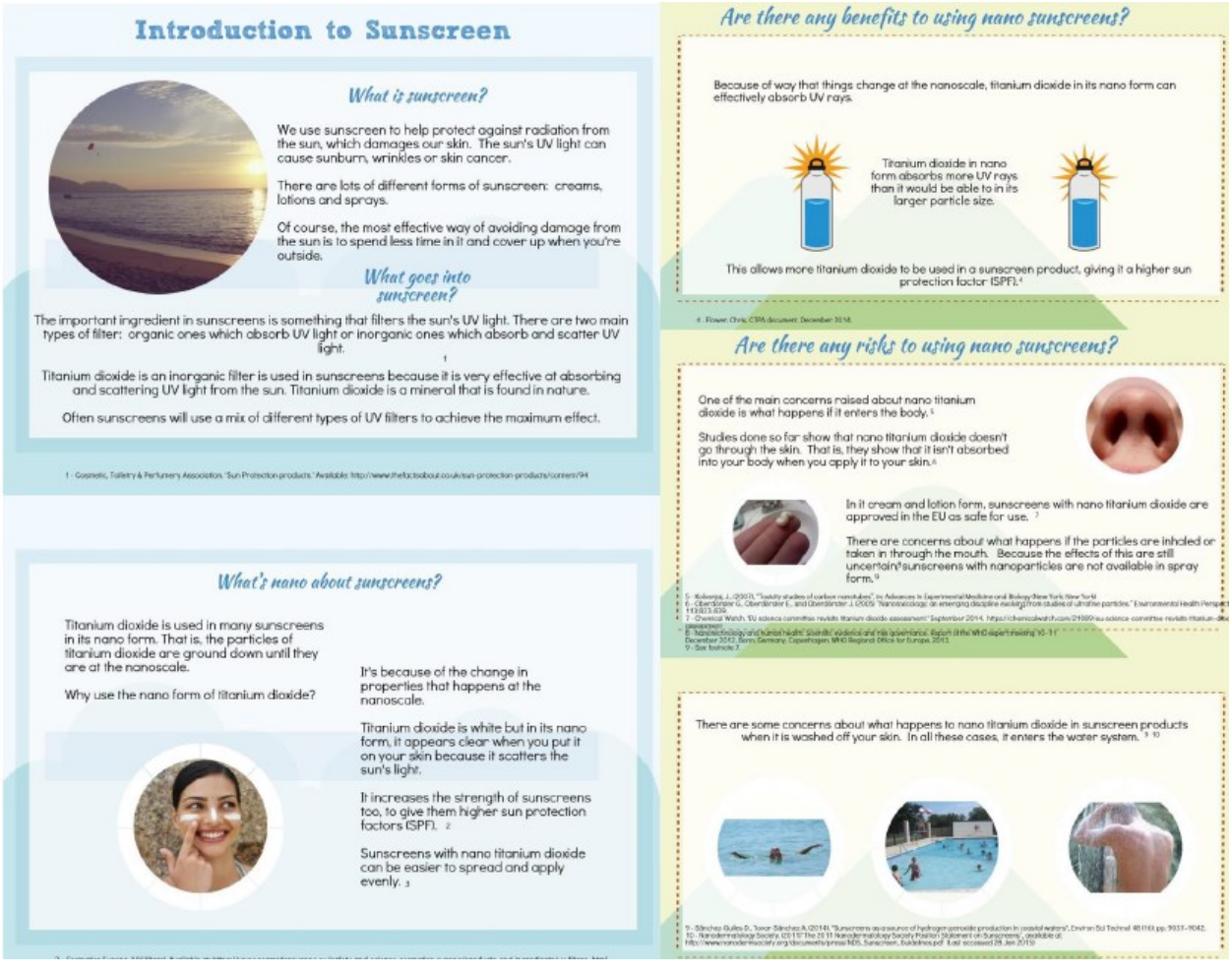
Figure 1.2: Example of Animation on Risk and Regulation in relation to Nanotechnologies



Appendix E: Application Posters




Introducing
Paints + Coatings
What are paints and coatings?
We use paint around our house to decorate the walls and freshen things up.
Coatings are often applied on top of paints - for example to protect them. Coatings are usually clear.
Everything from cars and ships to windows get painted or coated these days for lots of reasons: adding colour, keeping things clean or protecting them from rust, wear and tear.
What goes into them?
We make paints and coatings by mixing together different chemicals - each one has its own purpose like giving it colour or making it clear, helping it dry, or protecting surfaces.
What's nano about paints & coatings?
Nano has been in paints and coatings for a long time.1
Today nano is used in them to improve certain features. For example, some nanoparticles are good at resisting water and dirt. Others make surfaces self-cleaning.2
There are many different types of nanoparticles used in paints and coatings. Each one has its own properties.
Are there any benefits to using nano in paints and coatings?
Some particles in nano form react with sunlight so they are good at breaking down dirt and bacteria. This could be useful in hospitals to stop harmful bacteria growing. Or even, on the outside of windows or cars so they clean themselves. 3
Some paints and coatings with nano have other novel uses. For example, silicon dioxide is very strong in nano form. It can be used in coatings on cars to make them scratch-resistant. A nano titanium dioxide coating can make glass change colour when light shines through it. 3
Are there any risks to using nano in paints and coatings?
Some studies show that in the short-term nano in paints and coatings doesn't seem to cause any health problems.6
There may be issues to consider about what happens in the long-term if paints break down or are washed away. At the moment, research shows that very few nanoparticles are released from paints during wear or tear, by sanding or when spraying.7
Research shows that if some types of nanoparticles reach certain parts inside our body, they can cause harmful effects like inflammation. But this may not be true for all types of nanoparticles.8


Introduction to Sunscreen
What is sunscreen?
We use sunscreen to help protect against radiation from the sun, which damages our skin. The sun's UV light can cause sunburn, wrinkles or skin cancer.
There are lots of different forms of sunscreen: creams, lotions and sprays.
Of course, the most effective way of avoiding damage from the sun is to spend less time in it and cover up when you're outside.
What goes into sunscreen?
The important ingredient in sunscreens is something that filters the sun's UV light. There are two main types of filter: organic ones which absorb UV light or inorganic ones which absorb and scatter UV light.
Titanium dioxide is an inorganic filter is used in sunscreens because it is very effective at absorbing and scattering UV light from the sun. Titanium dioxide is a mineral that is found in nature.
Often sunscreens will use a mix of different types of UV filters to achieve the maximum effect.
What's nano about sunscreens?
Titanium dioxide is used in many sunscreens in its nano form. That is, the particles of titanium dioxide are ground down until they are at the nanoscale.
Why use the nano form of titanium dioxide?
It's because of the change in properties that happens at the nanoscale.
Titanium dioxide is white but in its nano form, it appears clear when you put it on your skin because it scatters the sun's light.
It increases the strength of sunscreens too, to give them higher sun protection factors (SPF). 2
Sunscreens with nano titanium dioxide can be easier to spread and apply evenly. 3
Are there any benefits to using nano sunscreens?
Because of way that things change at the nanoscale, titanium dioxide in its nano form can effectively absorb UV rays.
Titanium dioxide in nano form absorbs more UV rays than it would be able to in its larger particle size.
This allows more titanium dioxide to be used in a sunscreen product, giving it a higher sun protection factor (SPF).4
Are there any risks to using nano sunscreens?
One of the main concerns raised about nano titanium dioxide is what happens if it enters the body. 5
Studies done so far show that nano titanium dioxide doesn't go through the skin. That is, they show that it isn't absorbed into your body when you apply it to your skin.6
In it cream and lotion form, sunscreens with nano titanium dioxide are approved in the EU as safe for use. 7
There are concerns about what happens if the particles are inhaled or taken in through the mouth. Because the effects of this are still uncertain8 sunscreens with nanoparticles are not available in spray form.9
There are some concerns about what happens to nano titanium dioxide in sunscreen products when it is washed off your skin. In all these cases, it enters the water system. 9 10

Appendix F: Example Discovery Sheet

Environmental clean-up

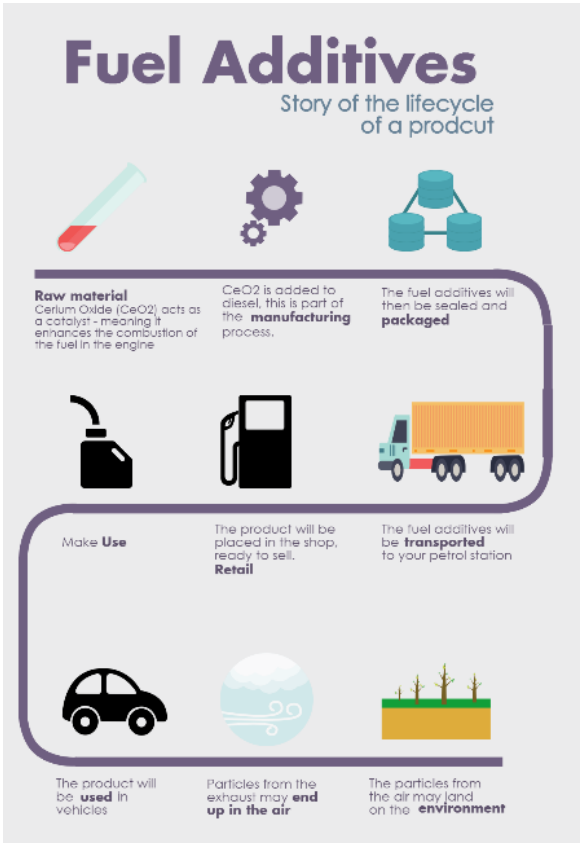
Why do we clean-up the environment?

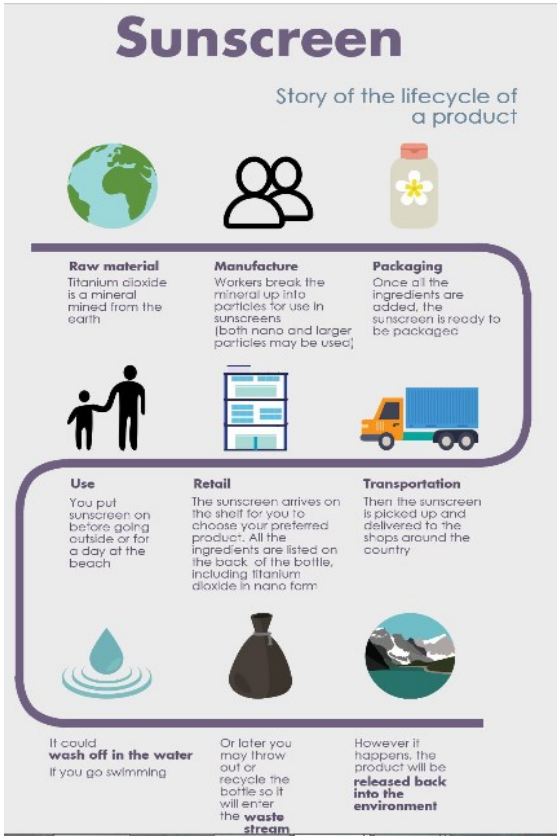
What do you think about environmental clean-up products containing nano materials?

Look at the product lifecycle, what points do you think are most important to consider here?

Jot down a couple of things you'd like to know more about.

Appendix G: Product Lifecycles





Appendix H: Scenarios/case studies

Environmental clean-up

Mary was fed up walking her son home from school every day past the ugly piece of land that used to be the petrol station. It was smelly and nothing had been done to it for ages.

"Look mum, there's a bloke in a high-vis jacket over there – what's he doing?"

Mary saw the van in the corner with 'Environmental Clean-up R Us" painted on the side. Oh that's great, she thought, something's happening at last. Maybe they'll make it into a park for the kids – I suppose there'll be lots of old petrol in the ground though.

When she got home, she called her friend Ruth to talk about it. Ruth's daughter had noticed it too, apparently, and was just as excited about getting rid of the eyesore and thinking about what it could be.

Ruth said she'd read something in the local paper about using some new techniques to clear up the mess quickly and better. It was something to do with iron, but very very tiny – the reporter talked about the nanoscale, but Ruth didn't know what that meant.

Mary was really interested – it sounded great. But it was next door. If it's new, she wanted to know, did they say anything about testing? Do they know it's safe? Will it escape into my garden? The cabbages are coming up! Shouldn't they just use something that's been used a lot before?

Ruth said surely it's better to get the mess cleaned up quickly so the kids can play?

- What do you think the dilemmas are here?
- What do you think of Mary's concerns?
- What questions would you want answered if you were Mary?
- What do you think the reporter on the local paper should do next?

Fuel additives

Pat: "I'm going up to my mum's this weekend – she hasn't been well and I think she needs cheering up."

Lesley: "How are you getting there?"

Pat: "Well, it's a long way to drive, and I'm going on my own – I'm not taking the kids. So I might go on the train."

Lesley: "Why not go in the car? You could take your mum out then, give her a bit of a treat."

Pat: "Maybe. Bill's been tinkering with the engine and put some new stuff in that's supposed to make it work better. He's got his little book with the mileage and petrol in it – been keeping it for years. We've had our car for five years now and he reckons we're getting more for our money since he added this stuff. It might be cheaper to go in the car."

Lesley: "Well, there you go then – no contest. Trains are always full of noisy people on their phones anyway."

Pat: "I know – but I worry about all the pollution. It's the kids' fault. They're coming back from school talking about emissions and they make me feel guilty. But perhaps this new stuff Bill's put in the engine will help. It's got really really small particles – they're called nanoparticles. They're supposed to make the exhaust less harmful. He keeps going on about some coach company that's supposed to have saved lots on fuel. That means less pollution too, he says. I don't know what to think!"

Lesley: "Oh yeah, I read something about that stuff. It seems pretty good. But they don't know much about its effects on our health and the environment in the long-term. On the other hand, I guess fuel itself is pretty harmful – it can't hurt to try this stuff, can it?"

- What do you think of Pat's dilemma?
- What do you think of the arguments that Bill makes about the fuel additives?
- What do you think of the arguments that 'the kids' make about emissions?
- What else would you like to know?

Paints



Frankie: "I got the job! There's a few of us, we're going to paint that big white building in the precinct. They're using some special new paint."

Jo: "Good for you mate – been a while since you've had a large job like this. So what's special about the paint?

Frankie: "Something to do with the sun and the pigment in the paint being ground down very very small. When the sun shines on this paint, it makes it clean itself – it breaks down the dirt. So it won't need to be repainted so often and will look nicer for longer."

Jo: "Well that's not so good is it – less work for us if that happens."

Frankie: "Maybe. But I heard that the kids won't be able to graffiti on it either – they made a real mess of the east side of that building."

Jo: "How does it do that then?"

Frankie: "The bloke who hired me told me about it – nano, he called it. I don't remember exactly how it works – you know me and complicated things. I'm better with a paintbrush in my hand."

Jo: "How long does it last? I mean – I know you said it cleans itself, but all paint wears away – you should see the front of my house, it's peeling everywhere. What happens to these nano things when the paint peels?"

Frankie: "You know, I never thought to ask that. Or if you just get rid of the left over special paint in the same way as the usual paint. I'll see if I can find out. I need to check what equipment to bring as well – my face masks are worn out from the last job. Maybe they'll supply them so I don't need to dole out money myself."

Jo: "Dream on mate! See you Friday night."

- What dilemmas do you think come up in this scenario?
- What other considerations do you feel are important for Frankie and Jo to think about?
- Do you think there are different issues raised when using paints with engineered nano or paints without?

Sunscreen



"Come on, kids! Into the bath." They were filthy. It had been a glorious day and they'd spent all of it in the garden.

Sally was trying to grow vegetables for the first time and Tracy and Max wanted to help. She gave them some lettuce seeds to plant but they got bored very quickly and wanted the paddling pool out. Apart from splashing each other and the dog, they made mud pies and a mess on the patio. Max had his dad's freckles and ginger hair, and Tracy was fair-skinned too. Sally was obsessive about using sunscreen.

She knew that they'd take off any T-shirts she tried to make them wear, and soon be stripped down to knickers and, if she was lucky, a sun hat. She didn't mind paying for a quality sunscreen and made sure that she bought the highest sun protection factor. She used the children's sunscreen on her own skin too. This time she chose a sunscreen with something called *nano titanium dioxide*. Usually she preferred to use organic things for her family, but she'd read somewhere that this nano stuff was supposed to be really good at preventing sunburn.

Later, Dad washed the kids in the bath while Sally cleared up the garden a bit. She emptied the paddling pool onto the lawn, which was looking a bit brown. She wondered to herself whether all the sunscreen that was in the water, creating a film on the top, would keep the worms from getting sunburned.

In the bath, the children were complaining about being crunchy and sticky. The soil had stuck to the sunscreen and they needed a good rub to get it all off.

"Where does it all go?" Sally heard them ask their dad. "Erm. With the water, down the drain," he said, "and then it goes in long pipes to a special place called the waste treatment plan. At least I think that's what it's called.-

Maybe it's a sewage plant. But that's where they clean all the water up and get rid of the waste."

"And what about the sun cream? Does that go with the mud? Or do they take that out?" asked Tracy. "I expect so," Dad replied.

"And can they reuse it?" asked Max. "Too many questions now. Up you get," Dad said. 'If only we had a scientist here,' he thought.

- What do you think are the dilemmas that come up for Sally when she's thinking about using sunscreen for her family?
- What considerations do you think somebody like Sally might have about whether to use a sunscreen with nano or without?
- Are there any other considerations you feel are important to take account of? (i.e. what do you think about the conversation the kids have in the bath or pouring the pool water on the lawn?).

Appendix I: Risk Cards

Sunscreen:

It could cause a health problem if it's on my lips and I swallow it.

It could harm the fish or other sea creatures if it washes off at the beach.

It could wash off in the shower and go into the water system, then who knows maybe end up in my glass of water and make me sick.

It might cause different health problems if I put it on my kids.

The people making it could get sick.

It could be absorbed through my skin and cause a problem, especially if I have a cut.

The info I have might be biased if not enough independent research has been done.

In the long-term there might be new risks I don't know about.

Sunscreen might get more expensive.

Too much money is being spent on a product that is fine as it is.

Environment:

There isn't enough science to properly understand the long-term risks.

We don't understand enough about how it works or what it will do in the environment.

It might end up in my food because it travels to the soil where my food is grown.

Children playing in the dirt might get it on their skin or in their mouths – and this might cause health problems.

It's impossible to detect so we might be exposed without knowing it.

It could build up in an area causing dangerous concentrations of iron.

It might not be safe for wildlife, trees, and plants outside the clean-up area.

There may not be enough regulation to monitor, track and enforce how the technology is being used.

It could end up in the water that I drink, then who knows maybe cause a health problem.

Paints:

The fumes might make people sick.

People might be exposed to nanoparticles when scraping off paint.

Nanoparticles might escape into the environment with unknown consequences.

Workers might get sick when making paints with nanoparticles.

Some paints with nano might be safer than others but it will be difficult to tell which ones.

There might be problems for the environment when we throw it out.

Some workers might become redundant because paints with nano last longer so there is less need for painters, etc.

We might lose the culture of street art and graffiti because anti-graffiti paints are possible with nanotechnology.

We don't know if there are any risks in the long-term.

Fuel additives:

I might get sick if I breathe it in.

If it's in the air all around us then it might end up in the soil and water.

It might build up in the environment without us knowing and this could be dangerous.

Fuel with nano additives might be more expensive.

It's impossible to detect so we might be exposed without knowing it.

The info I have might be biased if not enough independent research has been done.

In the long-term there might be new risks I don't know about.

The info I have might be biased if not enough independent research has been done.

World outside regulation:

Scientific uncertainties

Difficulties in the risk assessments needed for effective regulation

Economic potential

Environmental potential

Responsible innovation

Unintended consequences

Trust

What's missing from our discussion about regulation?

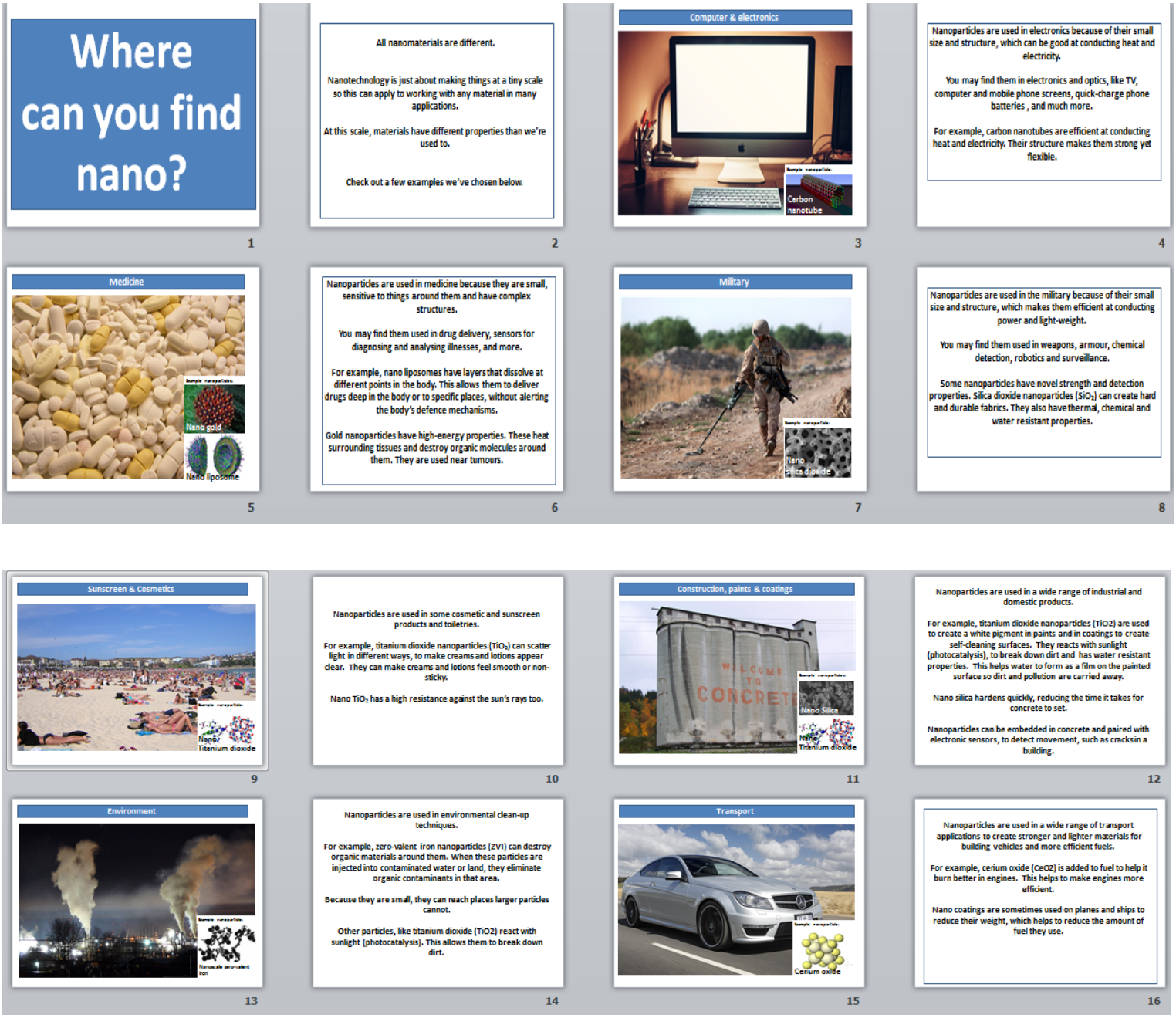
What are the broader implications of nano?

What are the wider questions?

Other:

Ask for any other concerns from participants.

Appendix J: Twelve Nanotechnology Areas[1]



[1] We used a culmination of sources to create these materials. These sources are listed in the Bibliography of this report.

Energy

17

Nanoparticles are used in the production and storage of energy and in energy saving.

For example, graphene is a nanomaterial that is a powerful conductor and generates electricity from heat and light. It is also thin, strong and flexible for construction.

Examples of nanoparticles used in the energy sector are solar panels and the conversion of heat to electricity (thermo-electricity).

18

Textiles & Clothing

19

Nanoparticles are used in fabrics because they have novel stain-resistant, antibacterial and waterproof properties.

For example, nano silver kills bacteria and helps to reduce smells!

Other nanoparticles, like nano silica, create a coating that repels water and liquids.

Nanoparticles are used to create new fabrics that stay clean and appear fresh for longer.

20

Food & drink

21

Nanoparticles could be used in foods and drinks to create foods with new flavours, textures or nutritional properties. They also occur naturally in milk and ricotta cheese.

For example, some nanoparticles can be engineered into forms that replace traditional ingredients, while keeping a familiar look or feel.

Or, they can add new properties, such as extended shelf life.

Other nanoparticles are used to deliver vitamins directly to cells in the body. Because they are so small, they are more easily absorbed than larger materials.

Engineered nanoparticles can be found in margarines, toffees and chocolate.

22

Packaging

23

Nanoparticles are used in some products because they provide antibacterial or gas barrier properties.

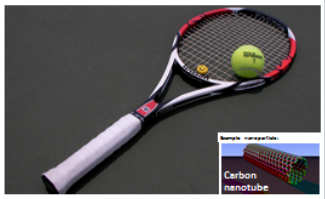
For example, silver nanoparticles added to packaging may help to reduce the growth of bacteria.

Nanoparticulate clay can be added to plastic to produce clear bottles or other packaging. This helps to stop carbon dioxide, which makes drinks fizzy, from escaping through the packaging.

Nanoparticles are used in food and drink packaging, from plastic beer bottles and food storage boxes, to fridges and coatings.

24

Sports & leisure



25

Nanoparticles are used in sports equipment because they are strong, light and hard when included in some materials.

For example, carbon nanotubes have 'tensile strength', which means they are both strong and flexible.

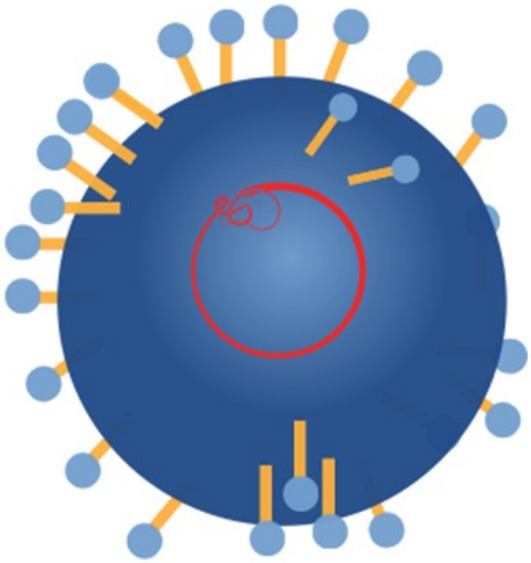
You may find them in tennis rackets, football and tennis balls, water jackets, exercise clothing and sails.

26

Appendix K: Timeline of Nanotechnology Development [2]

[2] This timeline was developed using a culmination of publically accessible sources. Two particularly useful resources included: Nano.gov, (2015), "Nanotechnology timeline", available at: http://www.nano.gov/timeline; Sutcliffe, H. (2015), "Nano & Me: Nanotechnology in our lives", available at: http://www.nanoandme.org/home/

Appendix L: "How small is small?" Examples of the nanoscale[3]



A virus is about 70 nanometres long.

Your fingernails grow a nanometre every second.

[3] These examples are based on information from Sutcliffe, H. (2015), "Nano & Me: Nanotechnology in our lives", available at: http://www.nanoandme.org/home/

Appendix M: "Talking Heads" and Regulation Animation Transcripts

Brief:

We will use Talking Head videos to support the process at several points throughout the public workshops. These videos feature a range of experts in nanotechnology providing the public with input from different perspectives and expertise backgrounds.

Firstly, we will use Talking Head videos on **Day 1** to give a general introduction to nanotechnologies. We will include essential initial information, like what is nanotechnology, how is it different from other types of technology, what are the key things/concepts we need to know to start discussing nanotechnology (i.e. Nanoparticles vs. nanostructures; brief history of its development, etc...).

We will introduce Talking Heads again in **Day 2** to talk about the four chosen application areas: Sunscreen, Environmental Clean-Up, Fuel Additives, and Paints. This part of the video will support the learning carousels when participants visit different stalls to learn about key issues and information relevant to each application. They could also be used later to support in-depth explorations potentially introducing a new idea or perspective to the discussions.

On **Day 3** the Talking Head videos will help us recap the journey so far. They can be shown at this point to review the content and stimulate again key points of discussion that have fed into the process over the course of the dialogue.

The Talking Head videos will be paired with facilitated deliberation to explore the public's perspectives, attitudes and aspirations on the issues.

Format:

Each video will feature one expert speaking on several different issues. The video will be able to be shown in different segments to support the appropriate point of the discussions. The issues are determined by the questions asked and what day of the workshops they will be shown.

Key questions and issues:

Day 1 (first workshop):

1. What is nanotechnology? (e.g. how would you define it)
2. How is it different from other types of technology?
3. What are the key things/concepts we need to know about nanotechnology to start our discussions? (I.e. Nanoparticles vs. nanostructures; brief history of its development, etc...)

Day 2 (second workshop):

4. How is nanotechnology used in this application area? (determined by area of expertise)

5. What are the key issues we should consider in this application area?
6. What is your perspective on its use and development?

Day 3 (final workshop):

7. What questions issues would you like the public to reflect on throughout the dialogue process?
8. How would you like to see nanotechnologies developing in the near future?

What is Nanotechnology? – Transcript

Jack Stilgoe:
Nanotechnology is to my mind it's the name that we would give to a collection of technologies that all in various ways that take advantage of novel things, new things that are happen at the very small scale - the nanoscale.

David Santillo:
Nanotechnology is the science and technology of extremely small scales including manufacture and use of particles and fibres at sizes of 1/10000th of a millimetre or less. These structures may be bound up in other materials or more freely dispersed, and it's their nanoscale, perhaps more even than their chemistry, which gives them special properties.

Roger Pullin:
Nanotechnology is in communications, electronics devices, some cosmetics and sunscreens, textiles, coatings also some food and energy technologies, as well as some medical products and medicines.

Jack Stilgoe:
So nanotechnology has enabled stronger, lighter materials. New varieties of chemicals that allow us to have a more effective sun creams for example. I think the bigger questions about how these technologies will be used in the future, rather than about what's here now.

What are the risks and benefits? - Transcript

Jack Stilgoe:
So if we want to imagine what nanotechnology will do for us – the benefits of it –because there's such a wide range of things that we would be talking about.

Roger Pullin:
Some of the exciting developments we could see are targeted cancer treatment, where we can avoid negative side effects, improvements in the way that we generate energy and also reducing environmental pollution.

David Santillo:
By enhancing the performance of materials, or introducing new properties, nano materials offer opportunities to increase the efficiency of industrial processes, reduce weight of materials without losing strength, and perhaps even to help tackle some long-standing problems in the fields of environmental health.

Just as they offer novel opportunities, nanomaterials can bring new risks.

Steve Hankin:
Risks of course mean different things to different people. On one hand you have health, safety, and environmental risks. On the other, you have financial and commercial risks. The real risk in all of this of course is not considering those issues at the beginning of putting in strategies to address them.

David Santillo:
The very characteristics that make no materials technologically useful, also present us with huge challenges in measuring and controlling exposure and harmful effects.

Steve Hankin:
There is really a number of different factors that need to be considered. These range from chemistries involved, the surface properties, the morphology, the size, the solubility, and no two nanomaterials necessarily behave exactly the same

Jack Stilgoe:
In the case of environmental remediation, you know, if we're injecting nanomaterials underground to, say, clean up pollution spills. One of the questions that we might ask is, well, what happens to those nanoparticles? Where do they go? Where do they end up?

David Santillo:
The use of my materials in paints could mean greater durability, thinner and lighter coats, and the possibility of self-cleaning properties. But it is important also to ask whether we know the additional risk these products bring to those who manufacture and use them, and how we should handle the paint safely during refurbishment or disposal. In the case of vehicle fuels, adding the articles can increase efficiency and reduce emissions of some harmful substances and exhaust fumes. But what happens to those nanoparticles once they're lost through the vehicle exhaust and become dispersed in the urban environment themselves? Given their extremely small size, nanoparticles are hard to contain it even harder to monitor when they're released to the environment.

Steve Hankin:
So taking the correct approach to managing a risk really depends on what the nature of the exposure is – i.e. how people come into contact with the material. For example, with paints, it's about the person who is applying the paint to the surface. When it comes to fuel additives,

it's about the people who are on the street exposed to the air pollution that's coming from the vehicles. When it comes to sunscreens, it's about the individual applying sunscreen to their face on a daily basis. When it comes to environmental remediation, very few people would be exposed. It's more about ecological risks that need to be considered. So to mitigate the risk each of those exposures has to be understood and managed correctly.

So where do we go from here? - Transcript

Jack Stilgoe:
In the past we've had examples of technologies which have emerged in secret, if you like, or without much consideration of the broader social, ethical, or risk questions, and that means that technologies have done harm, or that they've benefited particular groups and not others, and the important thing about public dialogue – some form of democracy about these new technologies – is to ask a new set of questions, right, questions about, well where is this technology going? What sort of life is it going to give us in the future? And is that a life that we, as citizens, want?

Roger Pullin:
I would like the public to think about all the challenges the world faces and be open to the fact that nanotechnology can help address these. Nanotechnology is not new, regulation and strict guidance is already in place, including how to manage the potential risk.

David Santillo:
Nanomaterials are already in widespread use. Just how widespread they are is hard to tell, because despite concerns about possible harmful effects on the body and in the environment, there remain few requirements to label or even report their use.

Development of nanomaterials has proceeded well in advance of proper regulatory controls and in some cases ahead even of the development of reliable methods to measure and assess their biological effects.

Jack Stilgoe:
So as well as the risks of nanotechnology, we should also consider the uncertainties – so all the things that we don't know about and indeed may never know about, that we may come to realise too late.

David Santillo:
Uncertainty is inevitable that so far the benefit of the doubt has been firmly and hands of the company's manufacturing in using nanomaterials with far too little focus on first ensuring safety, minimising hazards, and avoiding unnecessary uses and exposures.
It is also essential that regulations catch up with uses, so that people can be more confident that their health and environment are properly protected by responsible and precautionary actions by governments.

Roger Pullin:
Well I think the gaps and errors that need further development in this field are already been filled by the huge volumes of research being done by the European Commission, our own government, us as industry, pressure group and others. And if we can all work together on this, there is a real opportunity for us to deliver massive economic, societal, and environmental benefits for our country.

About Regulation (animation) - Transcript

What's the purpose of regulation?

Robert Lee:

So markets normally provide us with the goods and services that we want, and they do a pretty efficient job at doing that. But occasionally we have to intervene in those markets – maybe because the goods are potentially harmful, or maybe because the goods could cause some damage to the environment, or we want to control certain sorts of services, and we do that by forms of regulation

What are the different types of regulation?

Robert Lee:

There will generally be different processes of regulation throughout a life cycle because there will be different conceived harms. So if we think about working with stuff in a laboratory or working with stuff in a factory, we will be worried about thinks like worker exposure. That will give different rules to the rules that we put in place when something goes on the market. When something goes on the market, we may decide, do we want it labelled? Do we want it freely available for everyone who wants it? We will control the point of sale. After that, in use, often products are not tightly regulated. Once we've bought them, we can do what we like with them, but there will become a point of disposal, and the question is – and it's a very tricky question – how well do we cope with things at the end of their life.

How does regulation apply to nanotechnology?

Vicki Stone:

So if we think about how nanomaterials are regulated at different points in the life cycle. So if we think about how nanomaterials are regulated at different points in the life cycle. At the moment, there are no nano-specific regulations for occupational settings. There are new regulations for consumers which require cosmetic companies to label their product about whether they contain nanomaterials or not. For the environment, the Environment

Agency, and organisations life DEFRA provide advice and support to companies about how they can deal with nanomaterials and release them, or dispose of them. But at the moment, there are very few strict regulations in that area.

Who creates the regulation?

Robert Lee:

So when we decide we need regulation that regulation has to be written into legislation – written into law. However, because very often we're dealing with products, and because products are supposed to freely cross the European market, very much of this legislation is not UK legislation, it's EU legislation.

Vicki Stone:

The European Chemicals Agency uses a process known as REACH, which is a Regulation of Chemicals and Hazardous Substances. It's a series of guidelines that companies have to abide by and provide information to ECA when their substance or nanomaterial achieves a certain volume on the European market. If they feel they don't have enough information to make a well-informed decision about the use of that product, then they can put in place some embargos, or some controls, about how that substance is used.

Robert Lee:

When the Royal Society and the Royal Academy of Engineering looked at this in 2003, they suggested a hiatus on using materials for environmental clean-up. And since that time, that moratorium, as it's called, has been in place. Interestingly, it's not in place everywhere: it's not in place in the USA; it's not in place in Germany.

Are there any gaps in regulating nanotechnology?

Vicki Stone:

Probably the most important gap when it comes to regulating nanomaterials in consumer products and in the environment is being able to identify nanomaterials in those complex substances or complex mixtures. They're so small, they're really difficult to detect. So therefore it's difficult for regulators to find out exactly how much nanomaterial is included in a product, what it is, and then how it's disposed of.

Robert Lee:

There is only so much that Britain, or even the European Union, can do. Because the development of nanomaterials will go on a global scale, they will be produced in products that will be used in other countries and other environments; they may make their way into the market. But it is important, if they're entering the European market that European regulation applies to them.

Appendix N: Recruitment

Public recruitment: workshop quotas

We will recruit 40 participants who will participate in three separate, reconvened workshops. Participants will comprise an inclusive and diverse sample of the public that broadly reflects Birmingham's population in respect of: gender; ethnicity; age; socioeconomic grouping and employment.

Alongside these demographic variables we will also include quotas for attitudinal variables to be agreed with you, to ensure that the workshops achieve a diversity of views and perspectives on relevant issues (See below)

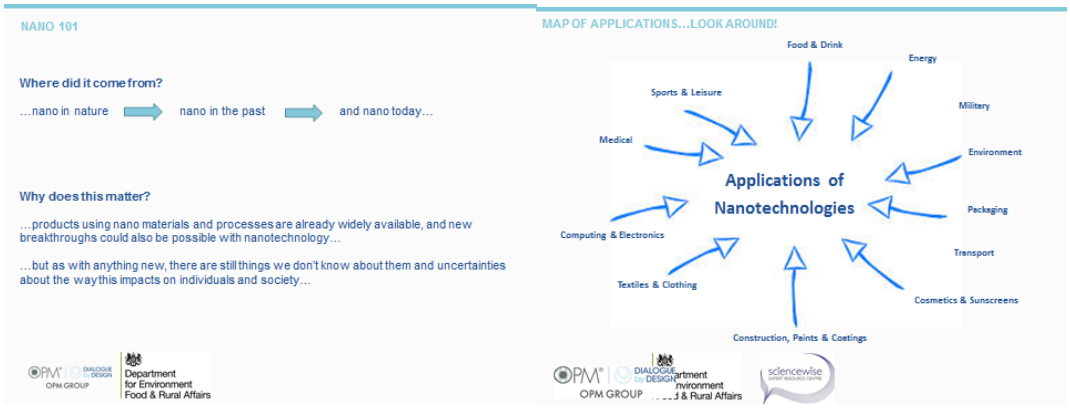
Recruitment will be conducted face-to-face.

Location (Regional Trends 2011, Office for National Statistics)	Location	Birmingham %	Actual number to recruit N	At least 6 rural participants Urban participants drawn from at least 5 different postcodes, rural participants drawn from at least 2 different postcodes.
	Rural	95%	37	
	Urban	5%	3	
Gender (Census 2011, Birmingham)	20 Male (49%) & 20 Female (51%)			50/50 M/F throughout (as close as possible)
Age (Census 2011, Birmingham)	Age bracket	Birmingham %	Actual number to recruit N	Actual numbers may range within 25% Number to recruit has been raised proportionality using the percentage figure
	18 to 29	20.2	11	
	30 to 44	20.8	11	
	45 to 59	16.4	8	
	60+	17.2	10	
Ethnicity (Census 2011, Birmingham)	Ethnicity	Birmingham %	Actual number to recruit N	At least 4 BAME participants
	White	57.9	23	
	Mixed	4.4	2	
	Asian	23.7	9	
	Black	7.2	3	
	Other	6.7	3	
Gross annual household income (Family Resources Survey 2012/13,	Gross annual household income	United Kingdom %	Actual number to recruit N	Actual numbers may range within 25% At least 7 low-income participants
	£15,599 or less	22	9	
	£15,600-	24	11	

	United Kingdom)	£25,999			
		£26,000-£36,399	17	7	
		£36,400-£51,999	10	4	
		£52,000 or more	22	9	
	Employment status (Census 2011, Birmingham)	Employment status	Birmingham Profile %	Actual number to recruit N	At least 3 other (which includes those off work due to disability or being a carer)
		Employed (inc. self-employed)	88.8	35	
		ILO Unemployed	11.1	5	
	Attitudinal questions	Are you member of an environmental organisation? (See list of environmental organisations)			No more than 3
		Which of the following do you own or use?			At least 5 who tick 2 or less At least 5 who tick 4 or more
		Do you work in any of these industries or professions?			No more than 3 from each industry or profession

Appendix O: Introduction presentation to nanotechnology

This presentation was delivered jointly by Dr. Paula Mendes and Dr. Iseult Lynch from the Univeristy of Birmingham.



Appendix P: Questions from Non-governmental Organisations (NGOs)

Jim Thomas, Etc. Group, Canada

- Nanotechnology is presented as an 'industrial revolution' in how materials are manufactured and used. But previous 'industrial revolutions' always have winners and losers and long term unexpected impacts that flow from the Economic changes underway. For example: The industrial revolution in Britain in the 18th century put craftspeople (e.g. cloth makers) out of work, created new urban pollution, moved people into cities, increased the demand for cotton which in turn led to the US plantation system and a booming slave trade and created a switch to the use of fossil fuels (particularly coal) which we now know changed the climate. On the other hand it made more and cheaper goods and created wealth for factory owners. Over the longer term what economic and social changes might follow from switching to nanotechnologies. What jobs are being replaced, what new forms of pollution are being created, who will be disadvantaged by the changes to come and do they have any say in decisions. Who will benefit most?

- One significant area of nanotechnology is nano biotechnology - re-engineering living systems at the nanoscale - e.g. creating 'living machines' or doing more extreme forms of genetic engineering such as Synthetic Biology and 'genome editing'. In synthetic biology companies are re-engineering bacteria, yeast and algae to behave like tiny living factories that produce food, cosmetic, drugs and fragrance ingredients. How do you feel about the ingredients in your food, cosmetics and soaps coming from vats of nano-engineered microbes. if a company replaces vanilla-flavour or orange flavour in a drink or skin cream with a synthetic biology -derived version what are the implications for consumers?, vanilla and orange farmers?, health and safety? The environment? The companies intend to label such ingredients as 'natural'. What do you think of that?

Peter Melchett, Soil Association, UK

- Have you thought about whether we need to develop nanotechnologies, and why?

- We don't know much about the long-term effects of nanoparticles. For example, whether they build up over time in the body or the environment and whether that could have negative impacts on our health or the health of wildlife. Given this, how would you want to see nanotechnologies developed?