Daniel Alexander

REF 2020

Portfolio

Scales of Resistance

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300 Word Statement

Scales of resistance is a piece of practice-based research by Daniel Alexander, working in collaboration with scientists at the University of Nottingham. The 7.51 minute film was scripted and directed by Alexander, and created in collaboration with the 3D imaging studio ScanLab Projects. It was exhibited at the Royal Society Summer Exhibition in July 2019.

Scientists developing bacteria resistant surfaces to combat antibiotic resistance were producing image data recording the behaviour of bacteria. This data would normally be presented to the public as 3D false colour illustrations. The scientists reported that this made the data seem less real to their audiences, and carried associations of cartoons, creating barriers to engagement.

Alexander comes from a photographic practice and wanted to research the possibility of operative images produced by 'seeing machines' such as microscopes, LIDAR scanners, Satellites etc to tell stories.

This project investigated and developed methodologies for visually communicating scientific information to the public, without resorting to illustrative imagery, and researched the possibilities of re-purposing operative images for narrative means.

A two-year process of bid development identified the key scientific information to be communicated, and established a methodology of using architectural visualisation software to locate images captured at micro and macro scales in accurate spatial relationship to one another.

In grant public engagement funding from EPSRC and Wellcome Trust grants enabled the production of the film, which was created over a four-month period, involving close collaboration between the researcher, the scientists and the film production studio.

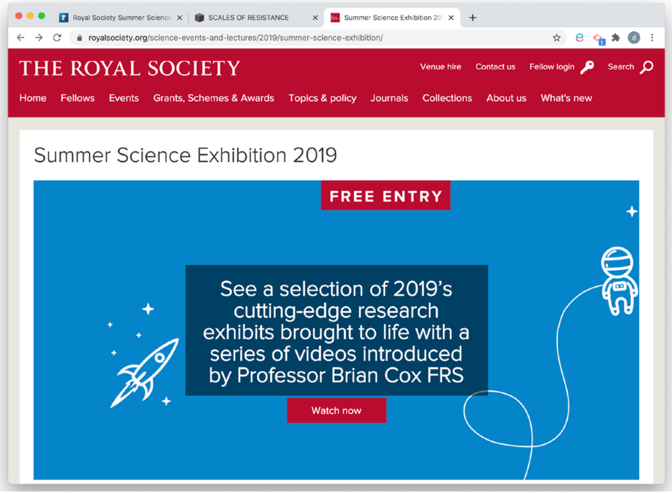
The film utilises the concept of the zoom to move a viewer through environments they are familiar with, into the human body then up to space. The use of original operative images maintains an indexical relationship to the environments depicted - a significant development from the usual reliance on illustration to communicate scientific concepts.

The Output

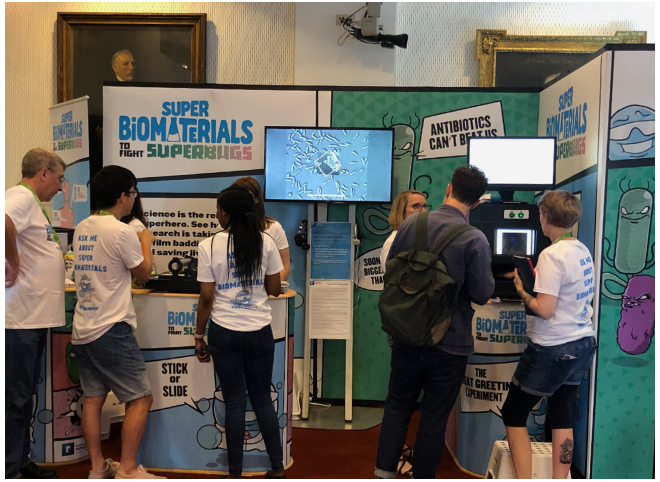
Scales Of Resistance: 07:51min
Director: Daniel Alexander
Research and Script: Daniel Alexander
Film Production: Scan Lab Projects
Sound Design: Kaspar Broyd @ String and Tins

Watch Scales of Resistance here:
https://scalesofresistance.info

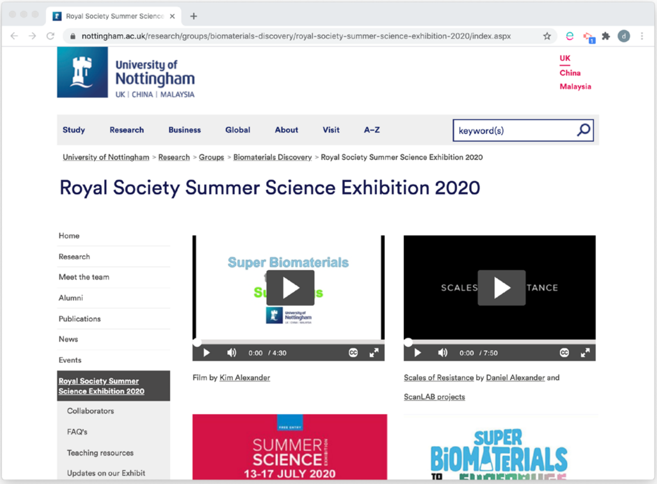
Sharing the Output: Exhibition of film and the online dissemination.



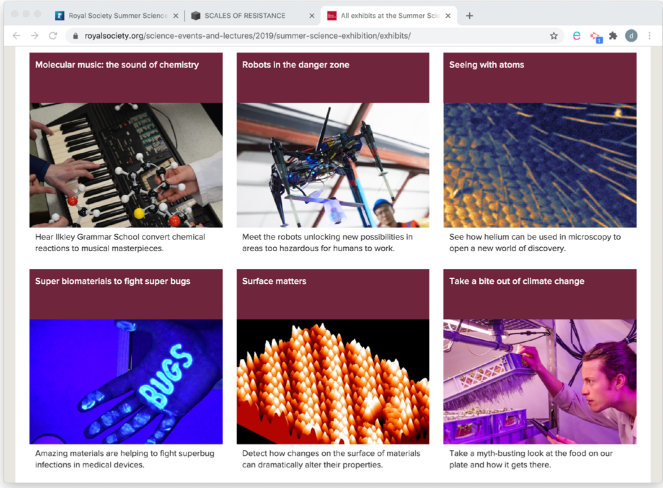
Film exhibited at the Royal Society Summer Exhibition 2019



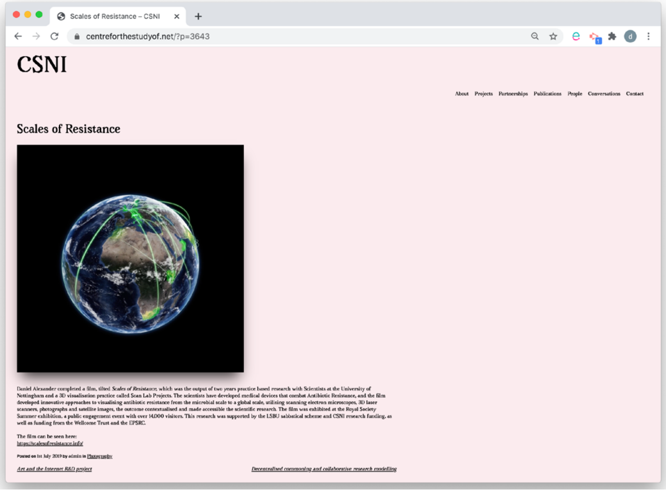
Film exhibited on the Super Biomaterials stand



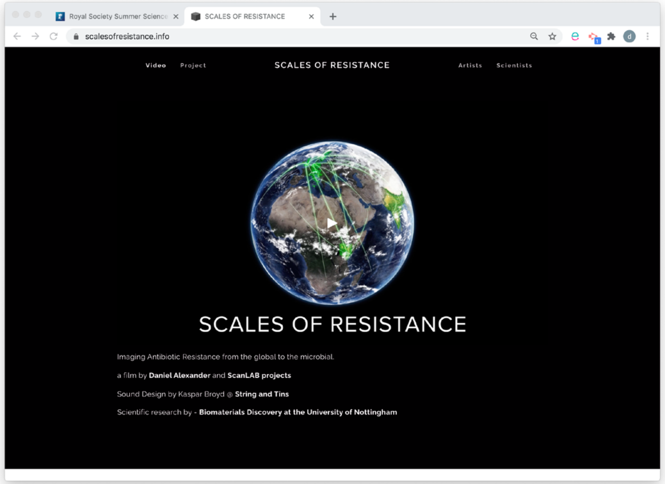
Project page at the on the UON webpage



The film was part of the Superbiomaterials to fight super bugs project



Project report on the Centre for the Study of the Networked Image

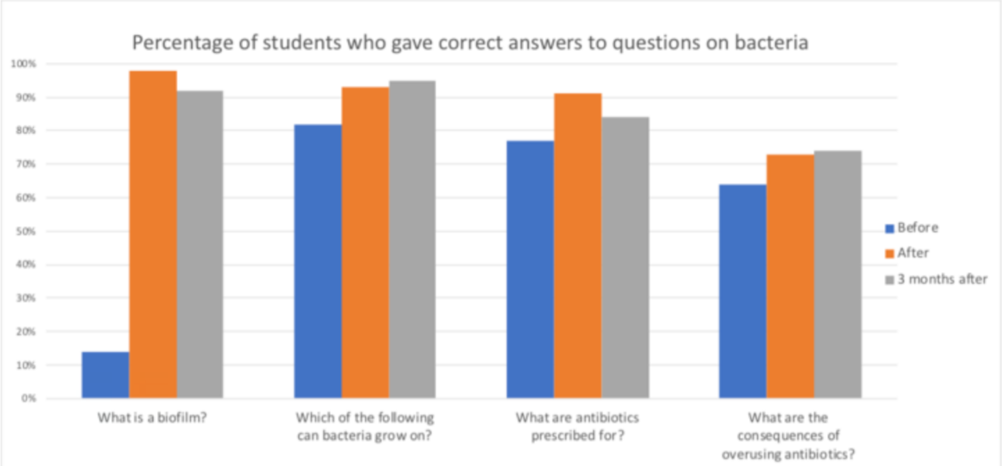


Dedicated project website

Sharing the Output: Royal Society Summer Exhibition: Impact study

In the summer of 2019, the Next Generation Biomaterials Discovery grant were busy finalising their exhibit for the Royal Society Summer Science Exhibition, a week-long event held in central London. As part of the fine tuning, they recruited the help of local Long Eaton School, to help assess the effectiveness and impact of the activities and information contained within the exhibit. Before the demonstrations began, the students were surveyed including questions regarding their attitudes and aspirations in science, as well as their knowledge of antibiotics, bacterial biofilms and materials. This same survey was then repeated afterwards, and then again 3 months after to explore whether there was any lasting impact.

Even 3 months after the initial demonstration to the students at Long Eaton school still showed an improvement in their knowledge of biofilms, bacteria, and medical devices, as they retained the information shared during the trial exhibit. Answers to questions on student's aspirations and interest in science also showed a positive shift, but not to the same significant extent.



Bar charts showing student responses before, after and 3 months after the exhibition on questions relating to bacteria.

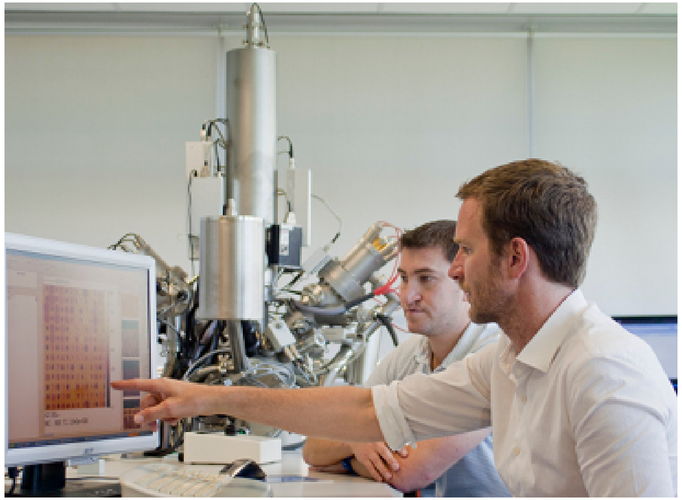
The funding for this project came from in-grant public engagement funding from the Wellcome Trust and the EPSRC. The scientists are the University of Nottingham were interested in using this funding to explore ways of communicating with the public. The film that I made was part of an exhibition at the Royal Society Summer Exhibition in 2019. The study reported to the left assessed the impact of the exhibition on school pupils understanding of the science.

https://www.nottingham.ac.uk/research/groups/biomaterials-discovery/news/2020/impact-royal-society-summer-science-exhibition2020.aspx

The Collaboration

Daniel Alexander was the lead researcher on this project, and brought together the collaborators. Daniel is an Associate professor at London South Bank University. He is a researcher, photographer, designer and film maker. Daniel collaborated with the scientists to identify how to best communicate their research, and how to contextualise the work they were doing within the global spread of antibiotic resistance.

Daniel then worked collaboratively with Scan Lab projects to develop a visual methodology that enabled the scientific data to be combined with other operative images across different scales.

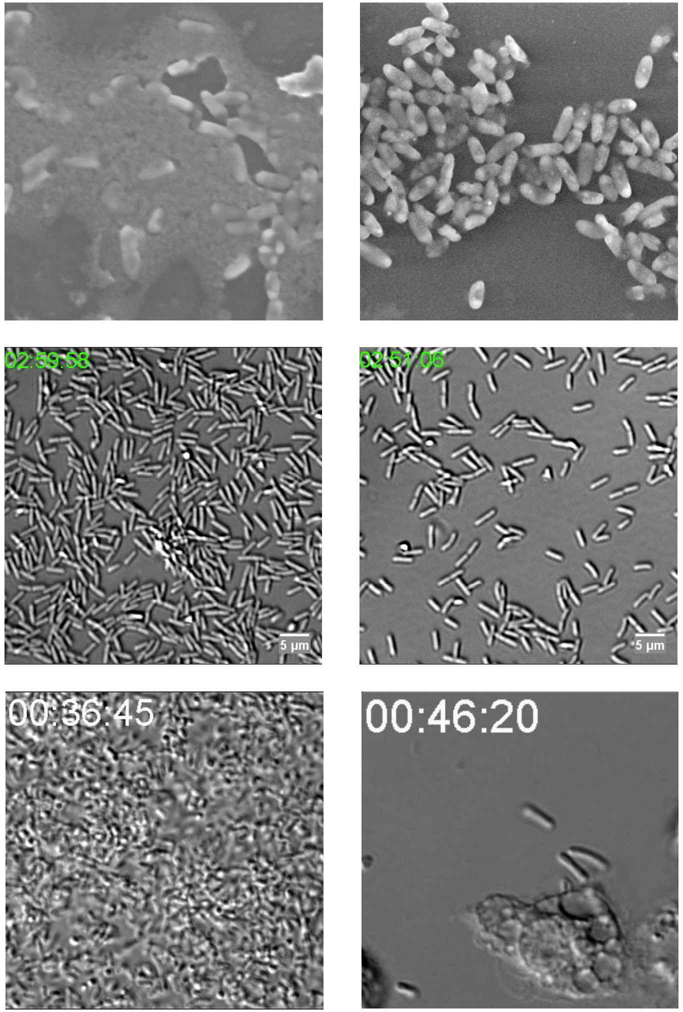


Prof. Paul Williams and Prof. Morgan Alexander hold a joint Senior Investigator Award to investigate why bacterial slime cities (biofilms) form on some materials but not others. Polymers discovered via a Wellcome Trust Translation Award are about to enter the clinic to help prevent catheter associated urinary tract infections caused by antibiotic resistant bacteria. The development of these polymers to coat medical devices and future materials emerging from the new scientific insights obtained provide examples of biomaterials development from discovery through translation to clinical use and mechanistic elucidation.
The joint Senior Investigator project is a multi-disciplinary programme using bacterial genetics and genomics alongside imaging mass spectrometry and advanced 3D microscopy to track individual bacterial cells as they explore surfaces and make decisions about whether to stick and develop into mature antibiotic resistant biofilms.

This research is supported by the Wellcome Trust and the Engineering and Physical Sciences (EPSRC) research council.

ScanLAB Projects are a creative studio who use 3D LIDAR scanning and photogrammetry to create 3D digital environments. Trained as architects they combine image creation with an ability to work in 3D spatial software, more commonly used for architectural visualisations. On this project they are collaborating with Daniel Alexander on the creation of the film.

The research objectives: Data to be communicated.



Silicon Rubber Surface

Surface coated with Bactagon

The Scientific Research:

The scientists involved in this project are developing materials that bacteria do not stick to. The application of this research will be for coating medical devices that are implanted in the human body, to reduce the instance of infection.

Global Context:

Many bacteria are developing resistance to antibiotics which until recently were the main defence against bacterial infection. Worldwide, antibiotic resistance causes 700,000 deaths per year, and it has been predicted that by 2050 this number could rise to 10 million deaths per year, unless urgent and effective action is taken. This means other ways of combating bacterial infection are needed.

Image Data:

The scientists study the behaviour of bacteria using scanning electron microscopy (SEM) and Differential interference contrast brightfield microscopy (DIC). SEM imagery produces highly detailed still images, where DIC enables rapid capture of many still images that can then be sequenced into moving image films.

The examples:

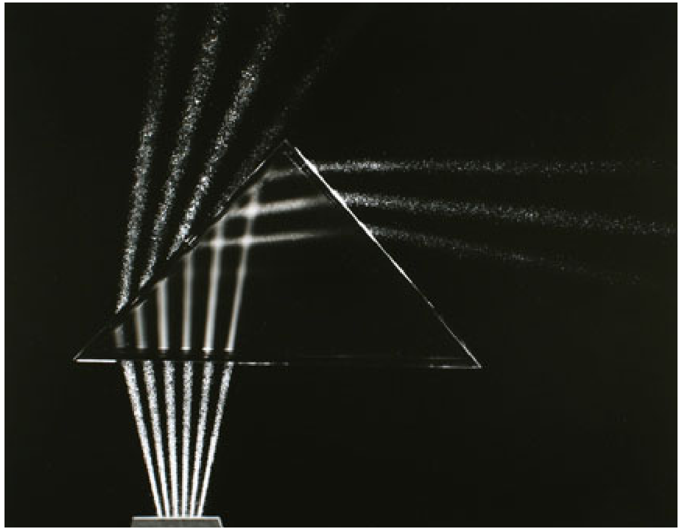
In these examples bacteria are forming biofilms in the left hand column, which overwhelm phagocytes, which are part of the bodies immune defence. In the right hand column ‘bactagon’ the material the scientists have discovered coats the surface and prevents biofilm formation. In the final image a phagocyte can be seen eating the bacteria.

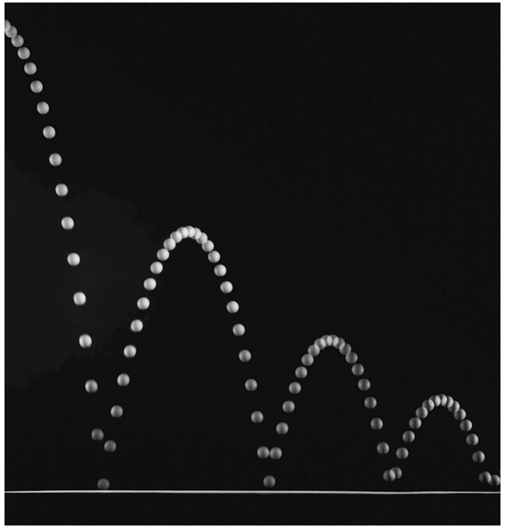
Research objectives: Developing an alternative to illustrative visualistaions.

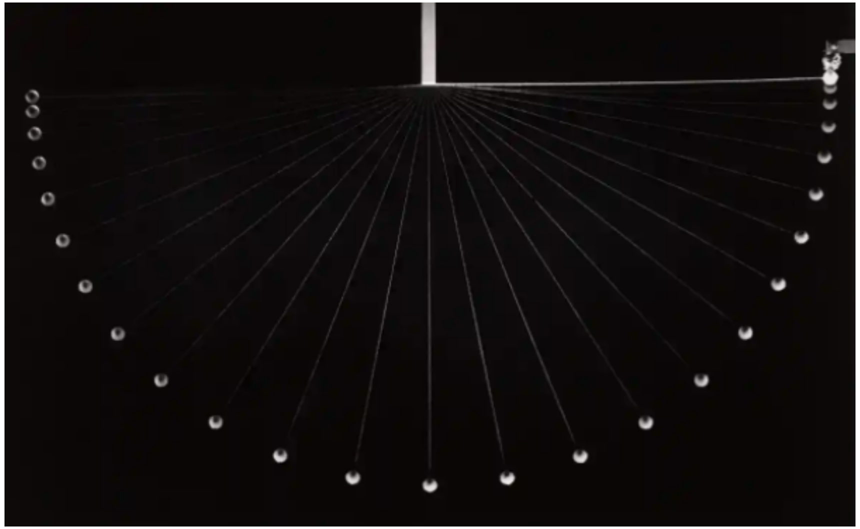
The problem we was trying to solve was how to communicate the scientific research without resorting to illustrative visualisations. The aim of the research project was to develop methods for using the original scientific imagery, which has a direct, indexical, link to what is being imaged, and enable it to be understood by the public.

The images here have been purchased from an image library and provide examples of a common way in which the image data included on the previous slides are visualised. These images are illustrations of bacteria, which take the form of bacteria and apply false colour to create pictures that can be used to explain how bacteria behave in the body. The scientists had identified that this style of imagery has an unreal feel to it, and creates some distance between the real world and its representation.

Research context: Building on a history of science photography.



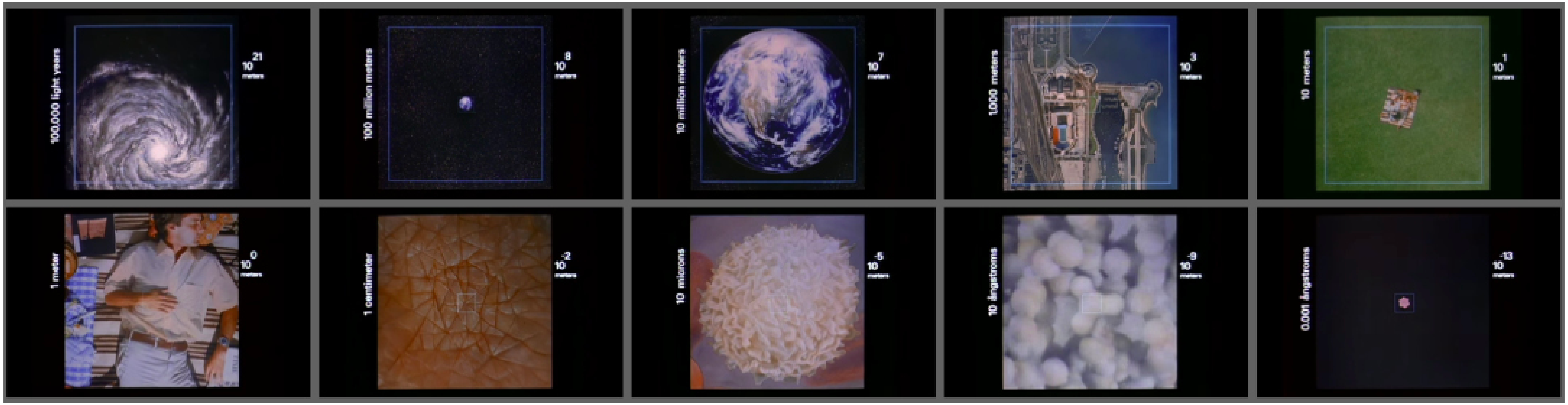




In developing a methodology for approaching the data we explored the idea of imaging as opposed to visualisation, in which the images have an indexical relationship to the object imaged, where as visualisations are non indexical representations of the object. Examples of imaging in photography include Berenice Abbott's strobe photographs that image how light and motion work.

'I wanted to combine science and photography in a sensible, unemotional way. Some people's ideas of scientific photography is just arty design, something pretty. That was not the idea. The idea was to interpret science sensibly, with good proportion, good balance and good lighting, so we could understand it.'
Quote attribute to Bereanice Abbott

Research context: Building on a history of science communication

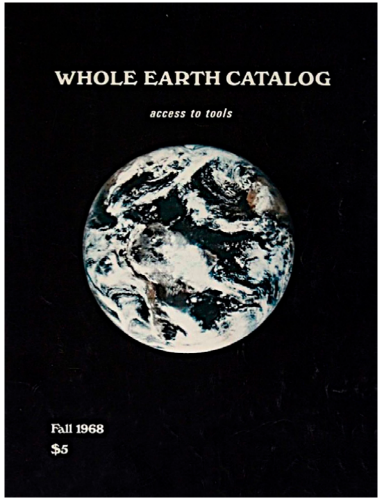


Our methodology built on to the work with scale that the 1977 Eames film *Powers of 10* had done. Here they applied the idea of moving into the body and out to the globe, using animated models to represent the scales that could not be imaged. We built on this idea of the zoom in and out by using real, operative, image data at all levels and by applying this method to communicate a specific narrative.

Research context: Building on a history of science communication

Earthrise, William Anders, Apollo 8, 1968

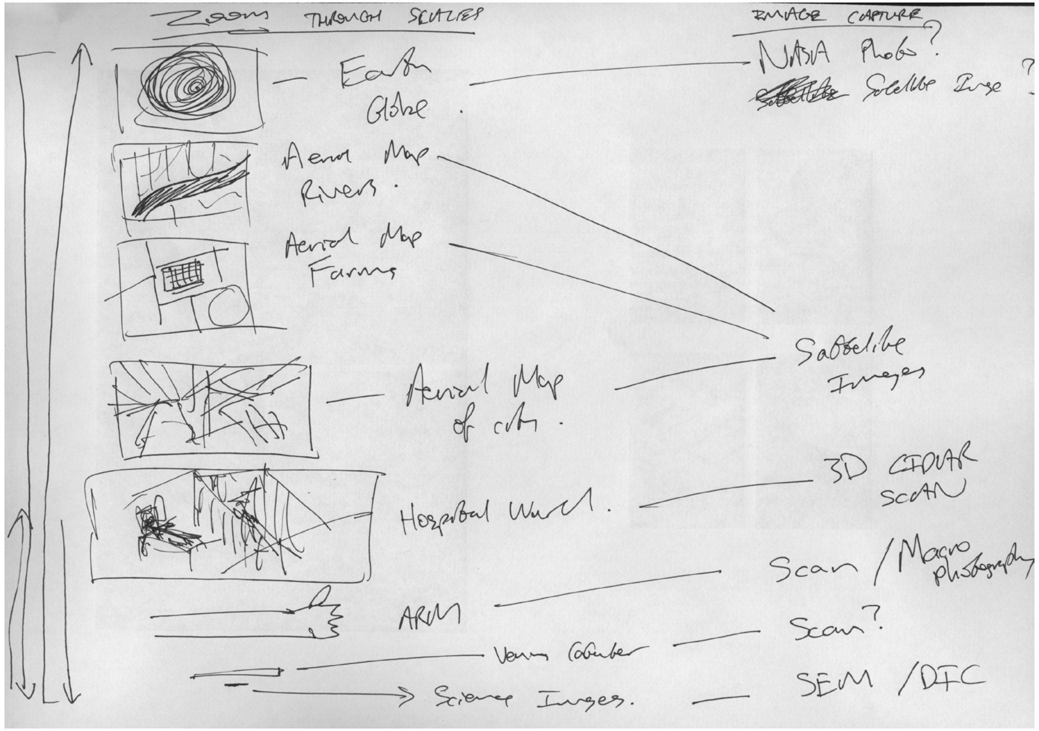
The Blue Marble, the crew of Apollo 17, 1972



Whole Earth Catalogue, 1968

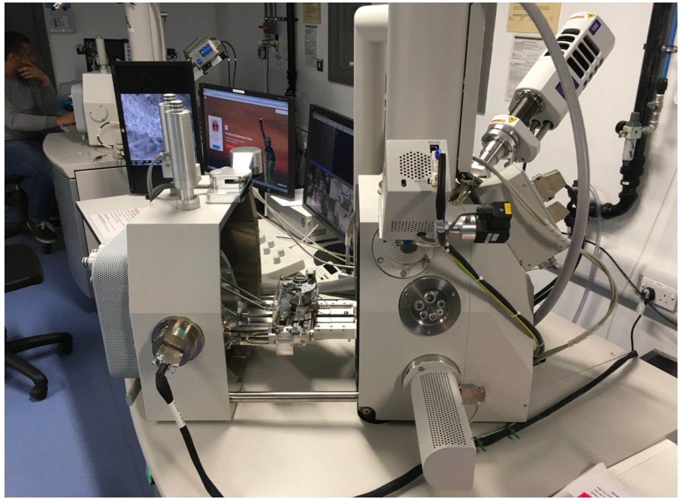
The visual method was developed to make reference to images which are part of a shared visual history, in order to reference ideas associated with these images. The photographs of the earth from space are associated with a moment in history when people were able to see themselves as part of a global collective and consider the idea of taking global climate action. The film references these images at the point when it is discussing the global impact of antibiotic resistance.

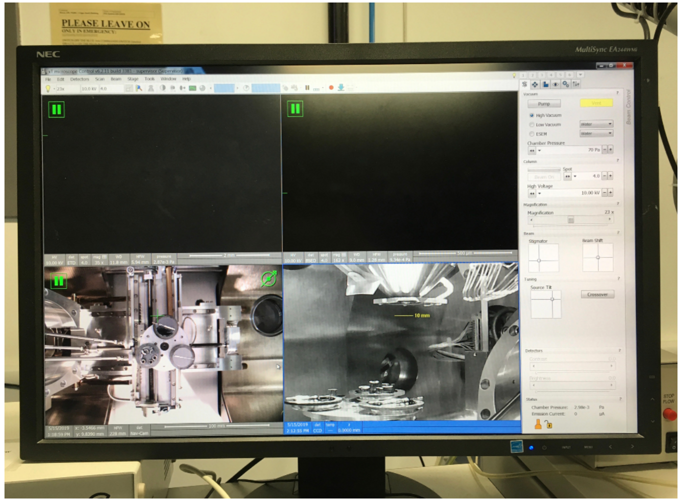
Process: image capture at additional scales.

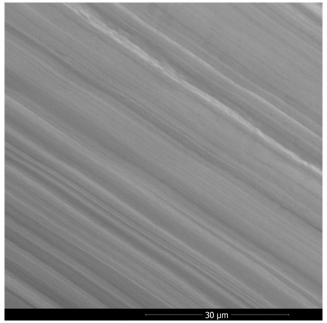


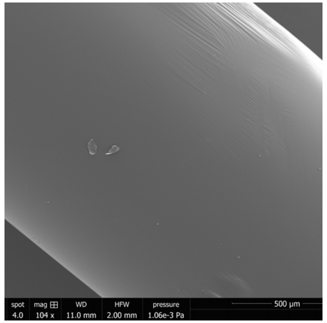
The process of creating the film involved identifying the range of scales that were needed to position the scientists research data, within the global context of antibiotic resistance. Once these scales were identified we then had to capture images at each of these scales, using methods appropriate to the methodology we were developing, of only using operative, not illustrative imagery. This sketch was the starting point of this research.

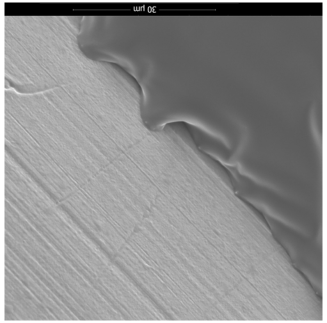
Process: image capture at additional scales.

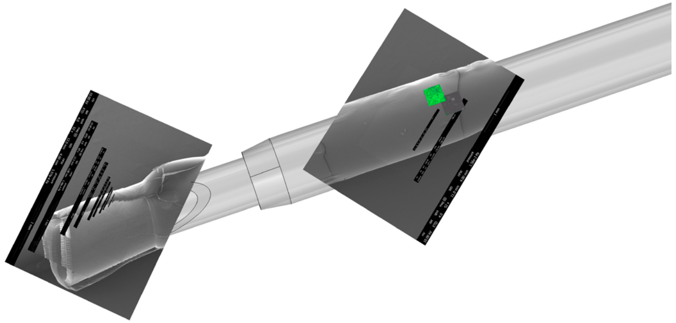












SEM imaging of venous catheters.

Here a scanning electron microscope is used to scan intravenous catheter surfaces, on uncoated and one coated with bactagon. These scans show the contrast between the textured surface of the uncoated surface and the smooth texture of the coated surface. These scans were created specifically for the film, in order to show the surfaces on which the bacteria would interact inside the body.

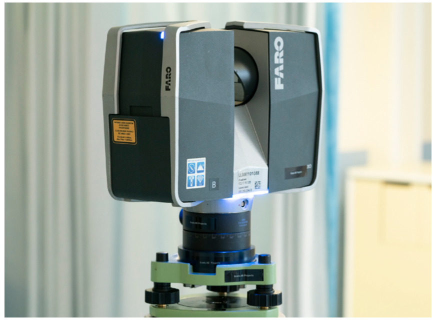
Process: image capture at additional scales.

Arm, Daniel Alexander

Photographic imagery of an arm.

Here macro photography is used to photograph the skin of an arm, at the site that a venous catheter would be inserted. Photography is used at this scale as it provides a link to the familiar, by depicting the skin through a medium an audience is used to seeing used for this purpose.

Process: image capture at additional scales.

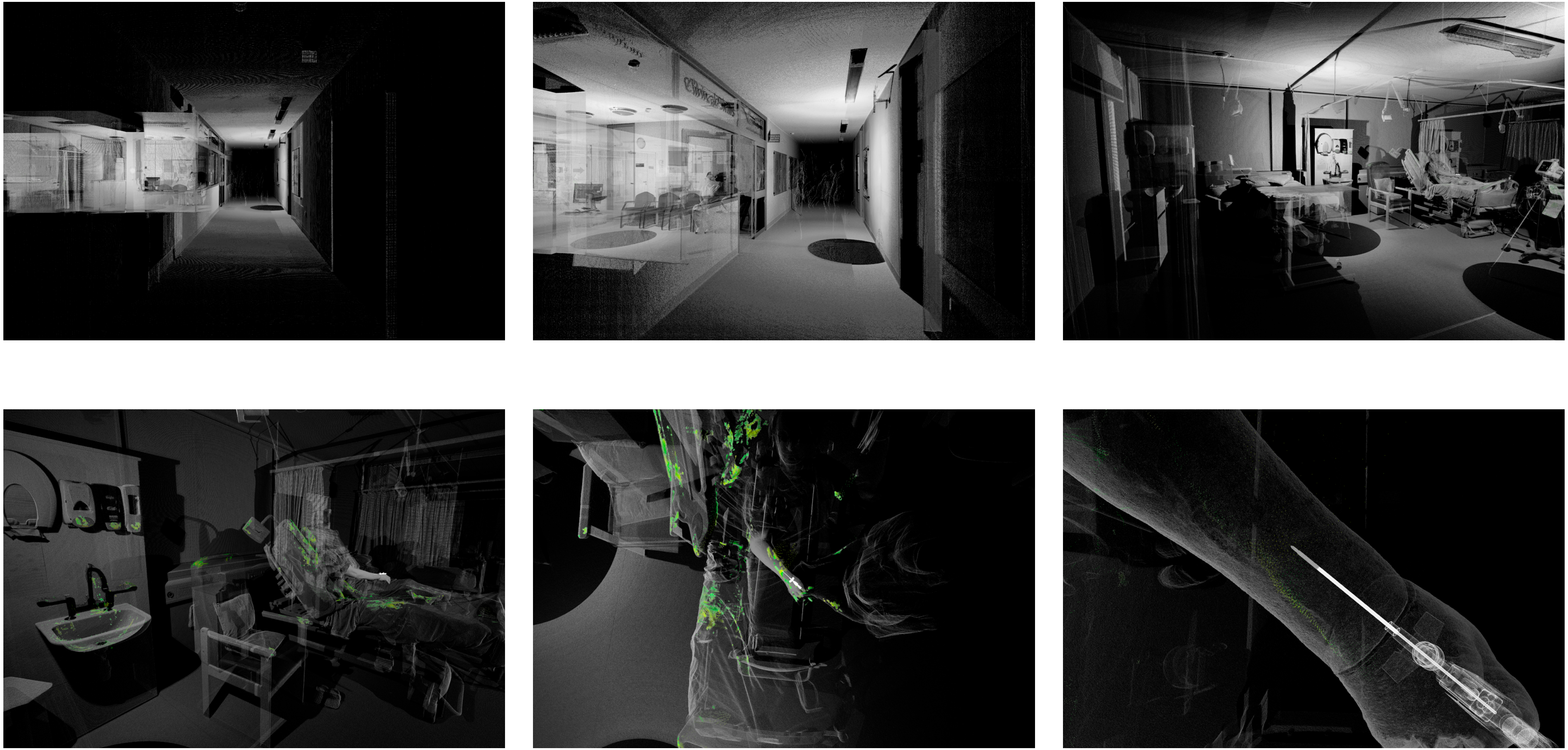


LIDAR scanning of hospital transmission experiment

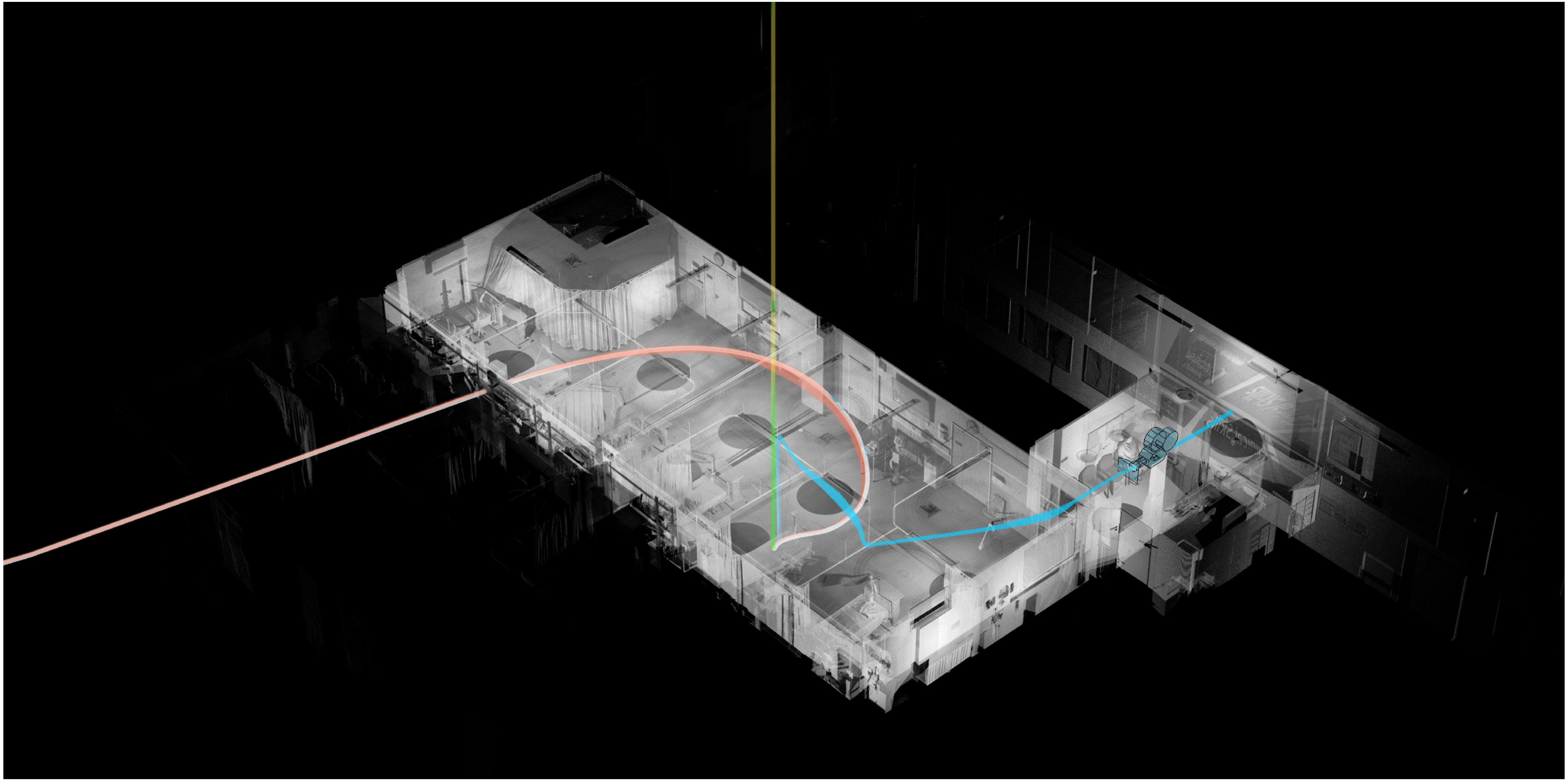
Here the scientists, Daniel Alexander and Scan Lab projects collaborated on an experiment, carried out in Nottingham Universities teaching hospital. Health care workers had their hands coated with a UV gel before carrying out routine patient examinations. After each examination UV light was used to view where the main touch points were, and how well the health care workers had washed their hands prior to carrying out the examination. Photogrammetry and LIDAR scans were created of the ward, recording the points where the gel had transferred from hand to surface.

Lidar Scanning enables a 3D image to be made of a space, and is used at this scale as it allows us to map the spread of bacterial through the ward.

Process: image capture at additional scales: Lidar Scans of Hospital Transmission



Process: image capture at additional scales: Lidar Scans of Hospital ward, with lines plotting the fly-through of the camera.

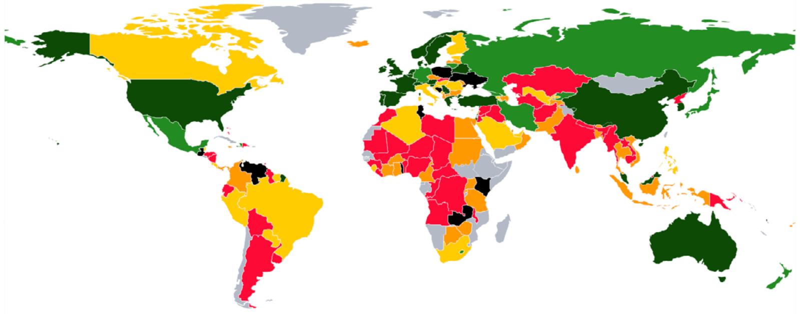


Process: image capture at additional scales: Mapping sites of antibiotic resistance: Cities, Farms, Rivers

Site: City/Farm/River	Latitiude	Longitude
Spain, *Madrid*	40°28'42.16"N	3°39'57.24"W
Argentina, *Buenos Aires*	34°36'4.44"S	58°22'44.92"W
USA, *New York*	40°44'37.62"N	73°55'50.04"W
Mexico, *Mexico City*	19°24'43.19"N	99° 5'36.16"W
Canada, *Toronto*	43°50'37.85"N	79°34'3.37"W
South Africa - *Karen Feedlot*	26°36'21.21"S	28°18'22.12"E
Russia - *miratog feedlot*	53° 3'0.62"N	33°56'3.89"E
Brazil - *JBS Guaiçara Feedlot*	21°38'27.07"S	49°48'22.88"W
Mexico - *Consorcio Dipcen SA de CV Feedlot*	18°35'6.74"N	96°24'59.39"W
USA - *McElhaney Feedlot*	32°41'19.56"N	114° 3'54.14"W
USA - *Randall County Feedlot Texas*	35° 3'49.18"N	102° 0'52.79"W
USA - *Coronado Feedlot*	36° 4'22.14"N	102°17'46.48"W
USA - *XIT Feedlot*	36° 0'9.80"N	102°36'43.26"W
New Zealand - *Five Star Beef Feedlot*	44° 1'43.74"S	171°50'6.17"E
Australia - *Lemontree Feedlot Feedlots*	27°47'19.52"S	151°16'52.52"E
Australia - *Beef City Feedlots*	27°31'29.07"S	151°37'13.98"E
Canada - *Lethbridge, Alberta, feedlot alley*	49°46'54.76"N	112°49'46.69"W
England, *The Thames River*	51°27'46.61"N	0°12'12.76"W
Austria, *Danube canal*	48°11'36.62"N	16°24'54.08"E
Austria, *Danube river*	48°23'17.54"N	15°32'8.26"E
Iraq, *Tigris River*	35° 7'8.21"N	43°32'41.32"E
Iraq, *Tigris River*	34°43'7.73"N	43°40'43.95"E
China, Yangtze River	30°16'7.01"N	112°16'41.05"E
China, Yangtze River	29°30'4.85"N	113° 3'50.67"E
China, Yangtze River	30°48'51.05"N	111° 8'40.51"E
India, Yamuna River	26°54'34.02"N	78°40'39.15"E
India, Ganges River	25°17'37.80"N	83° 0'25.30"E
India, Ganges River	28°36'3.28"N	77°17'35.63"E

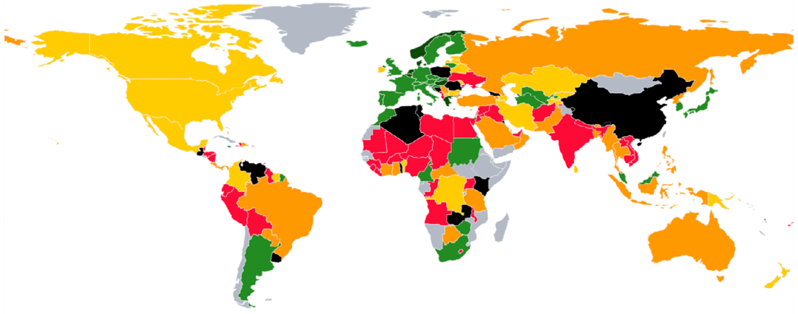
Satellite Imagery of Cities, Farms and Rivers.

Starting from the research lab in Nottingham Daniel Alexander identified locations worldwide that could be used to tell the story of the spread of antibiotic resistance and explain the causes. Drawing on research papers that investigate the impact of antibiotic use in animals, and the pollution of rivers with antibiotics, locations were then identified and satellite images downloaded.



7.1 National monitoring system for consumption and rational use of antimicrobials in human health

- A - No national plan or system for monitoring use of antimicrobials.
- B - System designed for surveillance of antimicrobial use, that includes monitoring national level sales or consumption of antibiotics in health services.
- C - Total sales of antimicrobials are monitored at national level and/or some monitoring of antibiotic use at sub-national level.
- D - Prescribing practices and quality of antibiotic use are monitored in a national sample of healthcare settings.
- E - On a regular basis (every year/two years) data is collected and reported on: a) Antimicrobial sales or consumption at national level for human use; and b) Antibiotic prescribing and appropriate/rational use, in a representative sample of health facilities, public and private.



7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

- A - No national plan or system for monitoring sales/use of antimicrobials in animals.
- B - Plan agreed for monitoring quantities of antimicrobials sold for/used in animals, based on OIE standards.
- C - Data collected and reported on total quantity of AMs sold for/used in animals and their intended type of use (therapeutic or growth promotion).
- D - On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, and by type of use (therapeutic or growth promotion).
- E - Data on antimicrobials used under veterinary supervision in animals are available at farm level, for individual animal species.

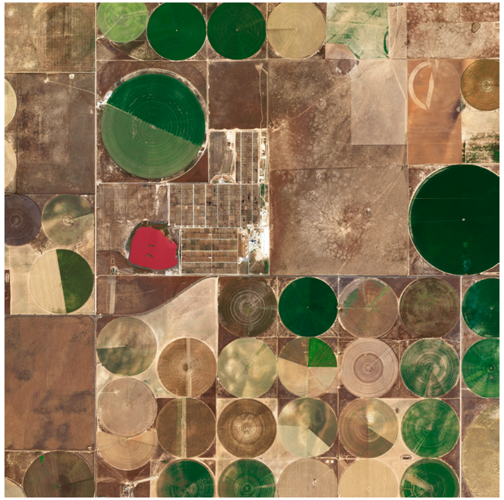
Global Database for Antimicrobial Resistance Country Self Assessment

Process: image capture at additional scales: Mapping sites of antibiotic resistance: Cities, Farms, Rivers

Spain, Madrid

Mexico, Mexico City

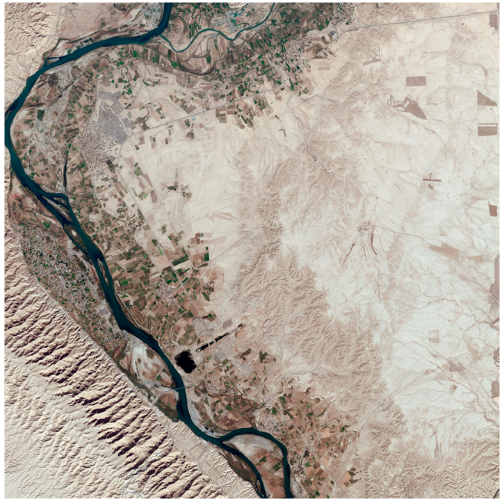
USA - McElhaney Feedlot



USA - Coronado Feedlot

New Zealand - Five Star Beef Feedlot

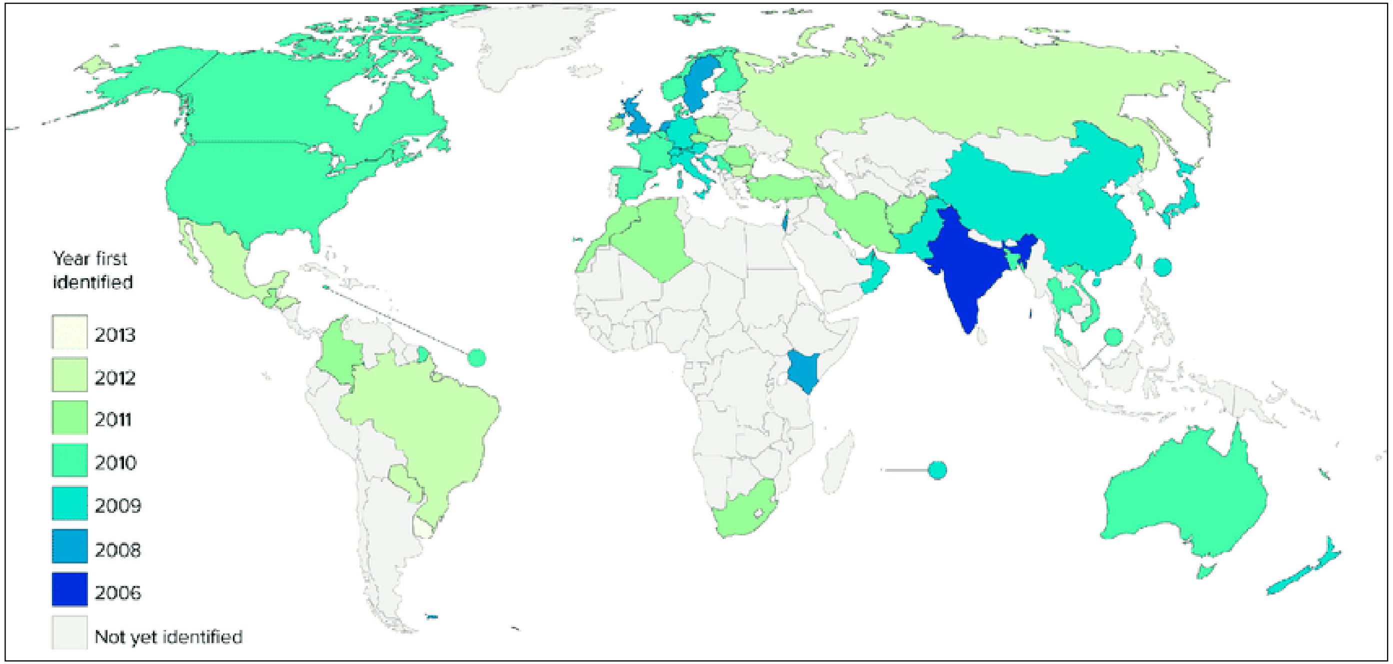
England, The Thames River



Iraq, Tigris River

India, Yamuna River

Process: image capture at additional scales: Mapping the spread of NDM1, an antibiotic resistant infection

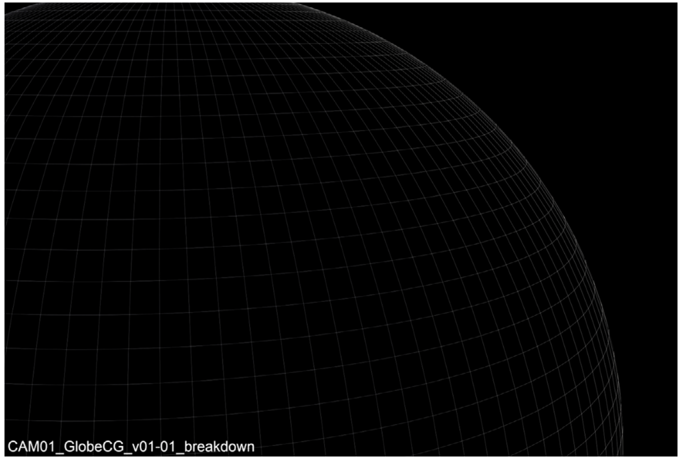


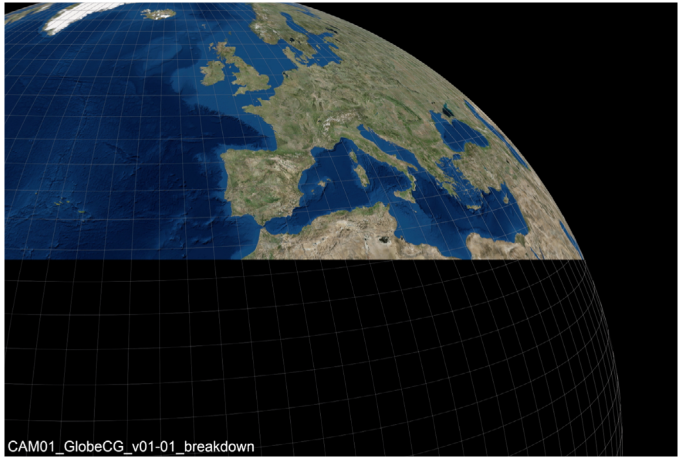
Global spread of antibiotic resistance.

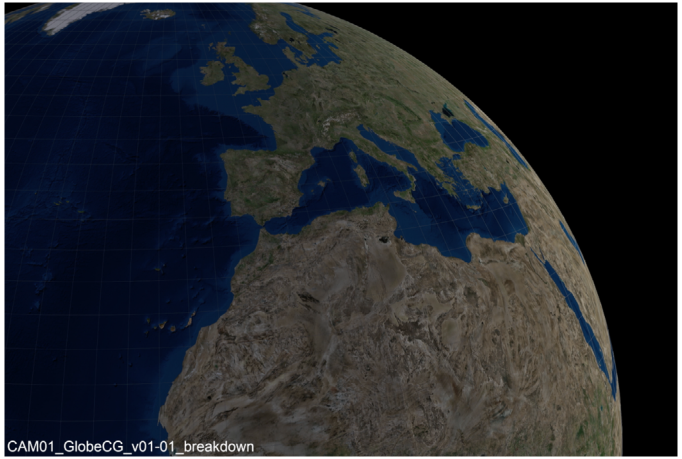
Research data was used to plot the spread of NDM-1 around the world.
Satellite imagery was again used to create a globe, on which this spread could be demonstrated.

Spread of New Delhi metallo-beta-lactamase-1: first detection Source: Johnson and Woodford 2013 (adapted)

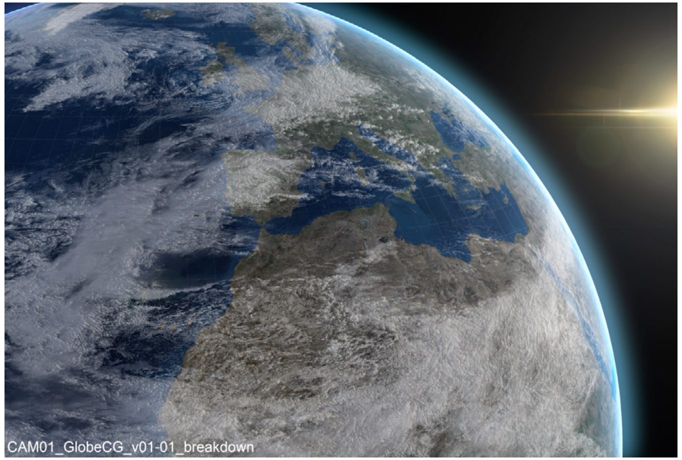
Process: image capture at additional scales: Mapping the spread of NDM1, an antibiotic resistant infection



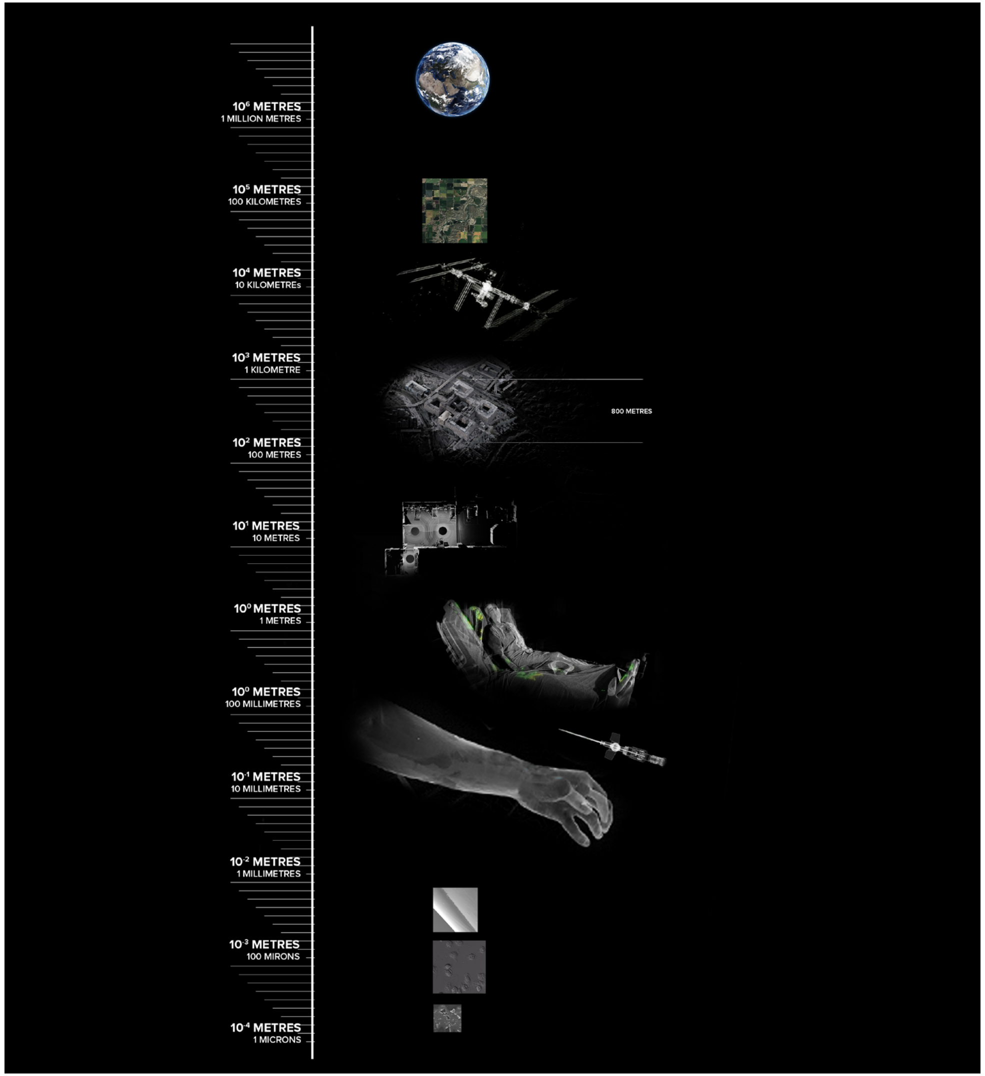




Spain, Madrid



Process: image capture at additional scales:



Final image scale:

Once all of the images were captured they were ordered by their exact scale and placed into a piece of 3D visualisation software and a camera path was built to fly through the images, seamlessly transitioning from one to the other. In a nod to the Eames film the Powers of 10, a white square was used to indicate scale at each of these scales.

SCALES OF RESISTANCE - script for VO

CAMERA	Voice Over
Black background *The camera moves along a number of hospital corridors, with jump cuts from corridor to corridor, then moves into a hospital ward.*	**INTRO TITLES** **Scales of Resistance:** **Imaging Antibiotic Resistance from the Microbial to the Global** **Antibiotic Resistance is a global problem that is reducing our ability to treat infection** **Fourteen in every one hundred people will contract an infection while in hospital and some of them will die.** **In Europe alone 37,000 people each year die from these infections picked up in healthcare settings.**
As the Camera moves into the ward the video transitions to the 3D b/w scan environment. The camera moves over to the sink, *The green marks start to animate onto the scan then across the other elements in time with the V/O - and as the camera pans across the patient in the bed, to the footboard at the end of the bed, then to the medial device stand.* *When the camera reaches the medical stand it pivots up and around so that its looking down on the patient on the bed*	This is a 3D laser scan of a hospital ward. UV hand gel was used in an experiment to map the places doctors and nurses touch when examining a patient. -- The green marks show where bacteria can spread if there is poor hygiene control. - the sink, taps, the patients bedsheets and pillow and medical devices can all become sites that harbour harmful bacteria ----

Script for Voice Over:

The script was developed in collaboration with the scientists and was used throughout the development of the visuals, then finalised and recorded once the film was complete.

Process: Script

SCALES OF RESISTANCE - script for VO

The catheter comes into shot in the bottom right of the frame and the camera starts zooming down towards it. *Initially zooming into the photogrammetry arm, Some green bacteria is visible on the catheter* *then the image of the skin comes into shot, and the catheter starts to animate towards the skin but then drops out of frame before it reaches the point where it would be inserted* *Then the camera moves through the skin to the catheter as the V/O says 'dragged'*	At 1meter square we are looking at a hospital patient with a venous cathter in their arm One in three hospital patients have one inserted into their body to take blood and deliver fluids. Bacteria can get onto the catheter when it is handled, and when the catheter pierces the skin bacteria in the hair follicles can be dragged into the body.
The camera moves through the skin into either a CT/MRI scan of an arm or into the grey environment of the Scanning Electron Microscope background. The cannula moves into the frame and the camera zooms into its surface. At this stage we will be using SEM images of the surface of the cannula, where we will be observing bacteria forming biofilms and macrophages failing to eat them.	Using a scanning electron microscope we can see beyond the range of human vision. here we can see extrusion lines on the surface of the plastic catheter. And here we can see bacteria attaching to the surface and starting to multiply Over time they form a biofilm, a slimy community that protects them from the bodies natural defences, and from antibiotics.

SCALES OF RESISTANCE - script for VO

	This is a phagocyte, it is part of the bodies defences and its job is to eat invaders such as bacteria. but here it is being overwhelmed by the biofilm. When bacteria form biofilms, infections can spread in the body and can cause severe illness and even death.
The camera now zooms out of the arm, *Breaking back through the skin on the line 'Modern Medicine' taking us back into the ward which no longer has the nurse next to the bed, but does have the traces of bacteria on the scan.* *The camera moves out of the roof, leaving the roof open so we still see the ward, using the square of the curtain rail as a graphic box in the image, which links us to the graphic box of the roof of the hospital in Nottingham then transitions to a 2D aerial view of Nottingham.*	For the past 80 years our main defence against infections has been antibiotics. Modern medicine relies on antibiotics for treating and preventing infection, for example during routine surgery and cancer treatment. But these medicines are becoming less effective as all around the world people have been overusing them, failing to finish the prescribed course, and using them for illnesses they cannot treat.
The camera then starts cutting from city to city while continuing to slowly zoom out. Each city should zoom out while also panning from left to right, which will be the eventual direction of spin of the globe. *The camera then starts cutting from farm to farm while continuing to slowly zoom out.*	At one kilometer square we can see the patterns made by large scale cattle farming Worldwide millions of tons of antibiotics are given to livestock every year, to treat and prevent infection. Antibiotics have also been

Process: Script

SCALES OF RESISTANCE - script for VO

The camera is then cutting from river to river, *ending up on the Ganges, where it starts zooming out while also spinning as it follows the river around to New Delhi*	widely used to increase growth in animals, something that many countries have now banned. Human and Animal waste combined with leaks from factories manufacturing drugs has now polluted many of the worlds rivers with antibiotics. This overuse and misuse of antibiotics has made bacteria resistant to them. These resistant bacteria are called superbugs,
	And Superbugs developed in one place can spread across the world, making many infections very difficult to treat.
Sweden glows red, then India, then flight lines leap off from India to the 70 other countries which all become red. The camera continues to zoom out. *The flight lines fade leaving the countries red, The camera continues to zoom out.*	In this example we can track the spread of NDM1 from India to over 80 countries. NDM1 is an enzyme that spreads between bacteria making them resistant to our strongest antibiotics.
All countries now glow red	Antibiotic resistance has now been identified in every country on earth, and The World Health Organisation warns that 'we are heading for a post-antibiotic era,

SCALES OF RESISTANCE - script for VO

	where common infections and minor injuries can once again kill'
The red fades leaving a normal colour earth. The camera continues to zoom out so that we are looking at the whole of the earth. The whole earth continues to recede in the shot appearing small and fragile the cloud coverage is on, so that the image looks like the NASA 'whole earth' image.	TEXT OVER IMAGE **2019: Antibiotic resistance causes 700,000 deaths each year.** **by 2050: if no action is taken it is predicted that this figure will rise to 10 million deaths per year** **This is more than currently die from Cancer and Road Traffic accidents combined**
The camera will then start zooming back in on the slowly spinning globe, *on which different countries will be highlighted to indicate some of the key global responses at the current time.* *The camera passes through the international space station with some green bacteria on the toilet (if its visible on the scan)*	To combat this problem action needs to be taken at a range scales. Globally all countries need to change how they prescribe and use antibiotics. Individually we need to take steps to prevent infection, by regularly washing hands, preparing food safely and practicing safe sex. Meanwhile resistance continues to spread, and Superbugs have even been found on the international space station.
The camera continues to zoom in gradually approaching the UK	
The camera is now above Nottingham, the camera swings off its vertical access to reveal	At the microbial scale innovative research can offer new ways of preventing infection.

Process: Script

SCALES OF RESISTANCE - script for VO

the scale squares floating above the earth.	
The camera then approaches the boots building at an angle	Researchers here at the University of Nottingham
The camera zooms towards the building and into the ward	are developing super biomaterials to fight superbugs.
Zooming towards the patient with the catheter in their arm. The angle of approach could follow the angle the catheter is inserted into the arm	These biomaterials can be used to coat medical devices that will be inserted into the body.
The we are through the skin and have moved vertical to the catheter again - looking the SEM image of the catheter coating *Then looking at the catheter cut away*	Here we see the smooth surface of Bactigon, This cut away section shows how the biomaterial adds a protective coating to the surface of the catheter.
Then to the video of individual bacteria moving around	bacteria choose not to stick to this surface
Then the still image of the lack of biofilm	And do not form a protective biofilm, instead remaining as individual bacteria.

Then to the video of the phagocytes.	This means that phagocytes, which are part of the body's defences, can eat bacteria and prevent infection.
Start zooming out - first through the large video of the phagocytes, then the SEM image of the coated catheter showing that the cannula did not really have a cut away while in the arm	Using this material to coat medical devices that will be put into the body makes it easier for the body to fight bacteria which helps to prevent infection and reduces the need for antibiotics.
Moves out to scan of the ward then the building.	Research is essential in the global fight

SCALES OF RESISTANCE - script for VO

	against antibiotic resistance. It leads to better healthcare outcomes, and saves lives.
Final screen which links to our web site for the RS expo, acknowledgments to funders, and lists the information sources for the stuff you include in the film. Sian can give you the list of acknoqledgements:)	