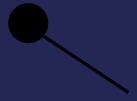
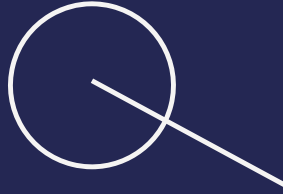
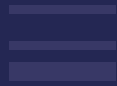
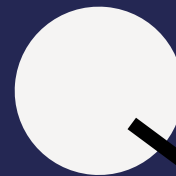




SILENT  
SIGNAL



SCIENCE  
GUIDE



SILENTSIGNAL.ORG



# SILENT SIGNAL



SILENT SIGNAL IS A GROUP EXHIBITION OF SIX NEW ANIMATIONS, EACH PRODUCED THROUGH A COLLABORATION BETWEEN AN ARTIST AND A SCIENTIST

THIS GUIDE HAS BEEN DEVELOPED TO GIVE FURTHER INSIGHT INTO THE SCIENTIFIC RESEARCH THAT IS EXPLORED IN EACH ANIMATION

LIVING NETWORKS EXIST ON MANY SCALES - FROM MICROSCOPIC TO GLOBAL. SOMETHING COMMON TO ALL OF THEM IS A NEED TO COMMUNICATE INFORMATION FROM ONE PART OF THE SYSTEM TO ANOTHER. THIS COULD INVOLVE MOVING A PROTEIN TO A NEW LOCATION INSIDE A CELL, OR AN INFECTION SPREADING THROUGH THE POPULATION OF AN ISLAND

Genetics is the language in which all biological communication is written. It is a chemical system, but its signals are silent. These signals are fundamental to how our bodies operate and how they adapt to fight disease. New technologies make it possible to listen to more of these signals, and biomedical scientists are steadily decoding this organic language. By becoming fluent in these signals, researchers can develop new ways to fight disease and improve global health.

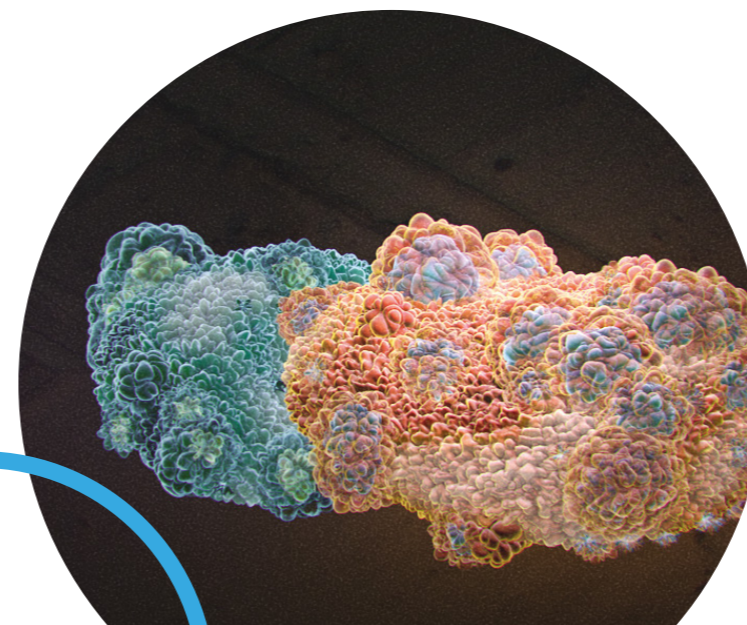
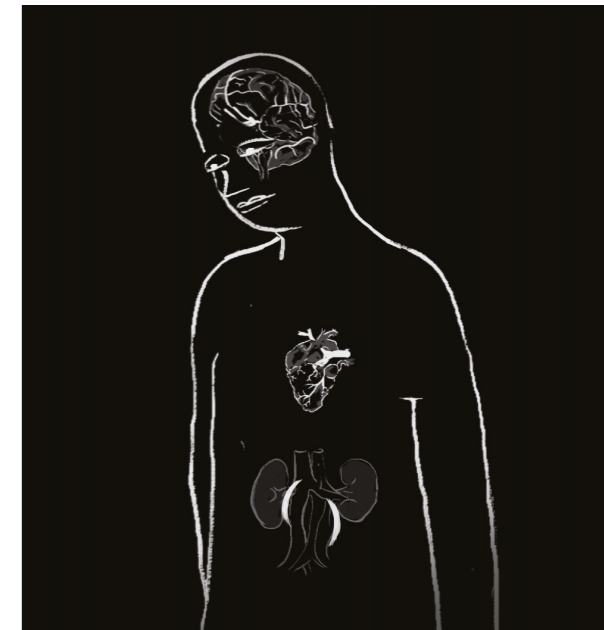
The Silent Signal biomedical scientists are each following different signals. They each use specialised machines and tools and their labs vary from digital models, tiny dishes in incubators to whole ecosystems and communities. Their approaches are as diverse as the signals they are chasing.

The animated artworks raise questions about what our genetic code is, how our immune system functions, how disease is spread, and what the future applications and impact of the research into these areas might be for us all.

Each work is the result of a close collaboration between an artist and a scientist, to produce an artistic response to scientific research across genetics, cell biology, immunology and epidemiology.

**BENTLEY CRUDGINGTON**  
Scientific Advisor

**GILLIAN PEARSON**  
Educational Consultant



FOR MORE INFORMATION, INCLUDING INTERVIEWS WITH THE SCIENTISTS, BACKGROUND INFORMATION, LESSON PLANS, CURRICULUM LINKS AND INTERACTIVE RESOURCES PLEASE VISIT [SILENTSIGNAL.ORG](http://SILENTSIGNAL.ORG)

Silent Signal is devised and produced by Animate Projects, and is supported by a Wellcome Trust Large Arts Award and the Garfield Weston Foundation.



# BATTLE OF BLISTER

GENETIC MOO IN COLLABORATION WITH DR NEIL DUFTON

"WE ARE THE BODY. WE ARE UNDER ATTACK." INFLAMMATION IS AN ANCIENT WAR CRY BUT WITH SUCH A CROWDED BATTLEFIELD HOW CAN THE BODY TELL IF IT IS WINNING AND WHEN IT IS TIME TO PUT DOWN THE WEAPONS?

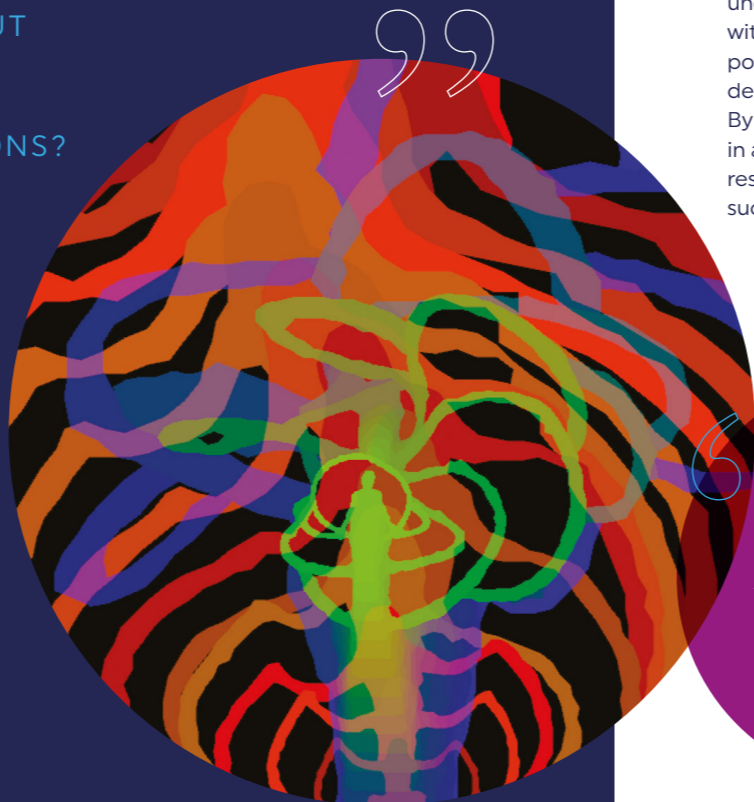
There are many types of soldiers fighting in this arena, all with their own specialised skills and weapons. These have been generated from human volunteers interacting with the blister cinema, exploring and responding to their environment to represent the complex signalling of inflammation.

## HOW IT IS MADE

Genetic Moo used Kinect sensors to record the silhouettes of performers. The artists wrote their own software to capture the motion data as it happened. At the editing stage, they were able to select, fine-tune and layer these sequences to produce the final 2D CG animated film.



DO YOU FEEL DIFFERENTLY ABOUT BLISTERS NOW?



DR NEIL DUFTON, RESEARCH ASSOCIATE, NATIONAL HEART & LUNG INSTITUTE, IMPERIAL COLLEGE LONDON

I AM A BASIC RESEARCHER, WHICH MEANS I AM INTERESTED IN BREAKING BIOLOGICAL PROCESSES DOWN TO THEIR BUILDING BLOCKS BEFORE TRYING TO APPLY THEM TO BIG PROCESSES, SUCH AS INJURY AND INFECTIOUS DISEASES. TO DO THIS IN THE LAB WE STUDY BIOLOGICAL ENVIRONMENTS THAT MAY, INITIALLY, SOUND STRANGELY FAMILIAR BUT ARE FAR REMOVED FROM TREATING PATIENTS IN THE CLINIC.

A blister is a perfect example of this. Many of us get blisters - from burning our mouths on hot food, from new shoes or insect bites. Bites can be more dangerous than you might think, because insects can carry nasty infections from animals or people, and inject them under your skin. Because of the constant threat of infection, the body has developed an immediate, pre-programmed response, called the innate immune response, which minimises the ability of infections to enter the blood stream. Most of the time our immune system gets it right. However, sometimes the communication between cells breaks down with adverse consequences.

My research has been focused on the cascade of events involved at the moment of infection: understanding how immune cells are mobilised within blood vessels and activated to fight any potential intruders, and, crucially, how cells are deactivated to allow tissue to be properly repaired. By understanding how cells coordinate these processes in a 'simple' blister we may be able to develop ways to reset the immune system in more serious scenarios such as chronic infection.

IS OUR BODY ALWAYS UNDER ATTACK?

IS OUR MODERN STERILE LIVING STYLE AFFECTING OUR IMMUNE SYSTEMS?

## GLOSSARY

### INFLAMMATION:

This is the starting point for both disease and healing, and a process everyone will be familiar with. A runny or blocked nose, swollen glands and lumps and bumps are all caused by inflammation. These swellings are caused by the immune cells that follow chemical distress calls from tissue that thinks it is under attack.

### INNATE IMMUNITY:

The immune system is how the body fights off attacks from diseases and toxins. The innate parts of this system are immediate and act fast against a wide range of pathogens; they don't need to learn their roles as they are already programmed in. When you are born, you automatically start to breathe, but you have to learn how to talk. You are born with your innate immunity, like the blister response, but other cells have to learn their role and these make up the adaptive immune response.

### CASCADES:

Just like water cascading over a waterfall, biological information needs to flow from one place to another. Cells use chemical messengers like runners in a relay team; the team can be made up of different cells or gangs of proteins inside a single cell. By studying who is in which team, what baton they use and who they pass it to, helps scientists to understand what causes a disease and how to stop it.

### FLOW CYTOMETRY:

When a light hits a mirror ball it reflects smaller beams of light all over the room. If you shine a laser at a cell the light also bounces back. The way a cell scatters light depends on its size and what is inside it. Flow cytometry collects these scatter patterns so that researchers can work out the amount and type of cells that are in a sample. Individual proteins in a cell can also be labelled with a glowing tag so the brighter the cell appears the more protein it contains.

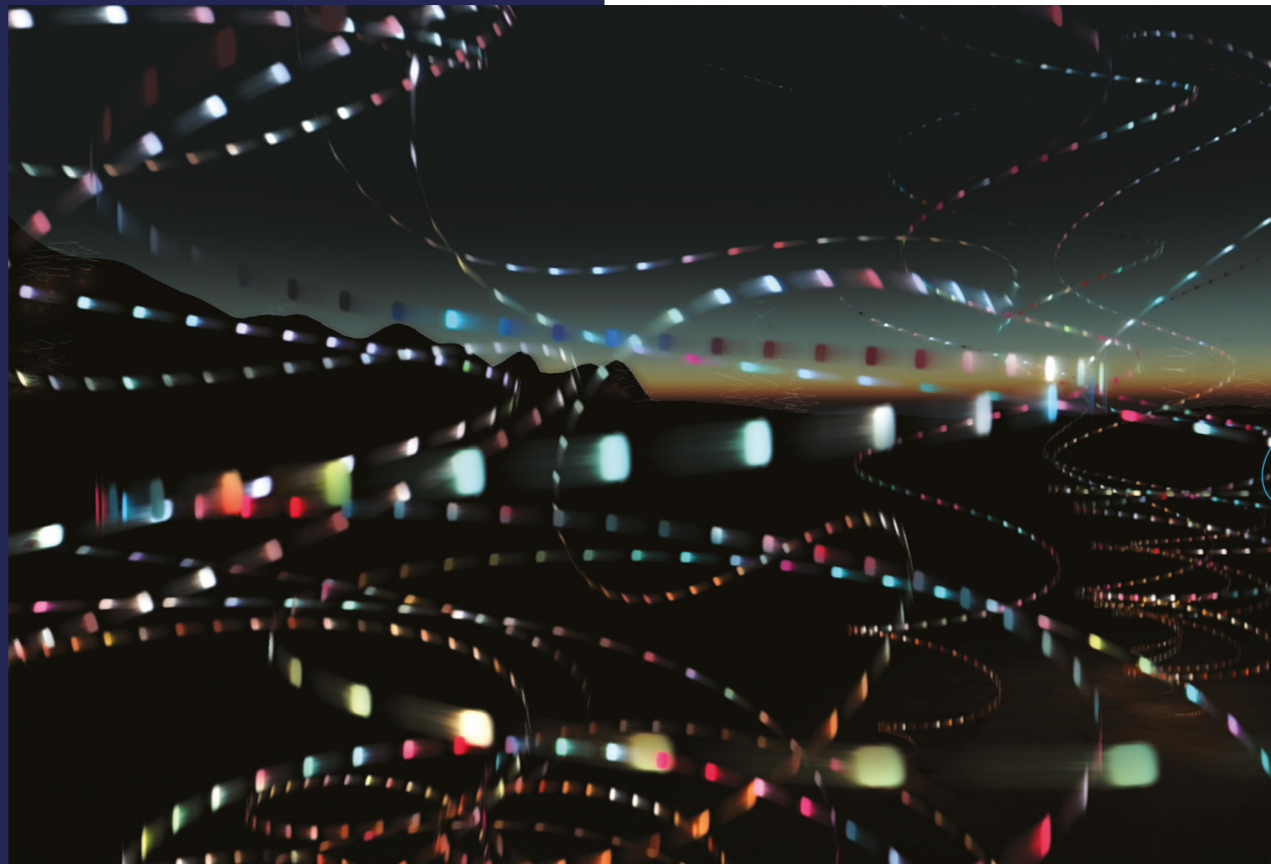


# AFTERGLOW

BOREDOMRESEARCH IN  
COLLABORATION WITH  
DR PADDY BROCK

INFECTIONS ARE NORMALLY INVISIBLE;  
ONLY THE DISEASE THEY CAUSE CAN  
BE SEEN. HOW DIFFERENT WOULD A  
LANDSCAPE LOOK IF INFECTIONS  
WERE THE ONLY SOURCE OF LIGHT?

Fluorescent labels are very common in biomedical laboratories. They let scientists see and track the things they are most interested in, from whole cells to individual proteins. Outside the laboratory, glowing packets of malaria light up this fictional landscape as swarms of mosquitos travel in search of their next blood meal.



“ SHOULD THERE BE MORE RESEARCH  
AND SUPPORT INTO NON-MEDICAL  
WAYS TO HELP REDUCE THE IMPACT  
OF DISEASE? ”

## HOW IT IS MADE

In the gallery, AfterGlow is a real-time animation being generated by a computer program that runs in a game engine. This program, that has been written by the artists, is informed by the scientist's infectious disease transmission models. For the version online, screen capture was taken from the real-time animation. The selected film capture was then compiled and edited into a 3D CG animation to show the accumulation of the infection transmission scenario.

“ IS HUMAN AND ANIMAL  
BEHAVIOUR JUST AS IMPORTANT  
AS AMOUNTS AND LOCATIONS  
WHEN THINKING ABOUT HOW  
DISEASE SPREADS? ”

DR PADDY BROCK, RESEARCH  
ASSOCIATE, INSTITUTE OF  
BIODIVERSITY ANIMAL HEALTH  
AND COMPARATIVE MEDICINE,  
UNIVERSITY OF GLASGOW

I WORK ON MALARIA, A PARASITE  
CARRIED BY MOSQUITOES. DESPITE  
THE SUCCESS OF CONTROL PROGRAMS,  
MALARIA STILL CAUSES SIGNIFICANT  
DISEASE AND DEATH AROUND THE  
WORLD, KILLING MORE THAN HALF A  
MILLION PEOPLE EVERY YEAR, MOST  
OF THEM CHILDREN IN SUB-SAHARAN  
AFRICA. I USE MATHEMATICS AND  
STATISTICS TO UNDERSTAND HOW  
MOSQUITOES SPREAD MALARIA, AND  
HOW WE CAN STOP THIS.

“ MALARIA IS A TREATABLE DISEASE,  
IS IT FAIR THAT HUNDREDS OF  
THOUSANDS OF PEOPLE ARE  
KILLED BY IT EVERY YEAR? ”

## GLOSSARY

### MATHEMATICAL MODELLING:

If there is not enough data available on a science question because samples are rare or hard to get, there can be too many unknowns to test individually. This is when building a model is very useful. Model simulations allow different ideas about how a system works and how one thing leads to another to be tested and compared with real world observations. Models can be simple or complex but are useful and powerful tools across all sciences.

### INTEGRATION:

Data can come from almost anywhere; patient medical records, community interviews, blood samples, satellite tracking and parasite DNA. These data will all look very different. Integration combines different types of data from different sources into the same model to help make it as accurate and useful as possible.

### $R_0$

(Pronounced 'R nought') is a measure of how likely a disease is to spread. It is the average number of people that will be infected by a single contagious person arriving into a new population in which nobody is immune. The value of  $R_0$  will change depending on how the infection is spread and the size, status, and movements of the population. Understanding who in a population is exposed, susceptible or infected is key to controlling an outbreak.



# LOOP

SAMANTHA MOORE IN  
COLLABORATION WITH  
DR SERGE MOSTOWY

“INSIDE A CAGE, INSIDE  
A CELL, INSIDE A WHOLE  
LIVING ANIMAL”

To understand a problem sometimes you need to change your scale and your perspective. The cells that make up all living things would be shapeless sacks without the cytoskeleton giving them structure. However it is more than just a scaffold. It allows cells to change their shape, to move and interact with each other. It forms the internal transport network that moves material around inside cells, and plays a crucial role in dividing the cell up into compartments - the cytoskeleton can even make cages that capture harmful bacterial invaders. Loop explores the diversity of this biological engineering and the people that study it.

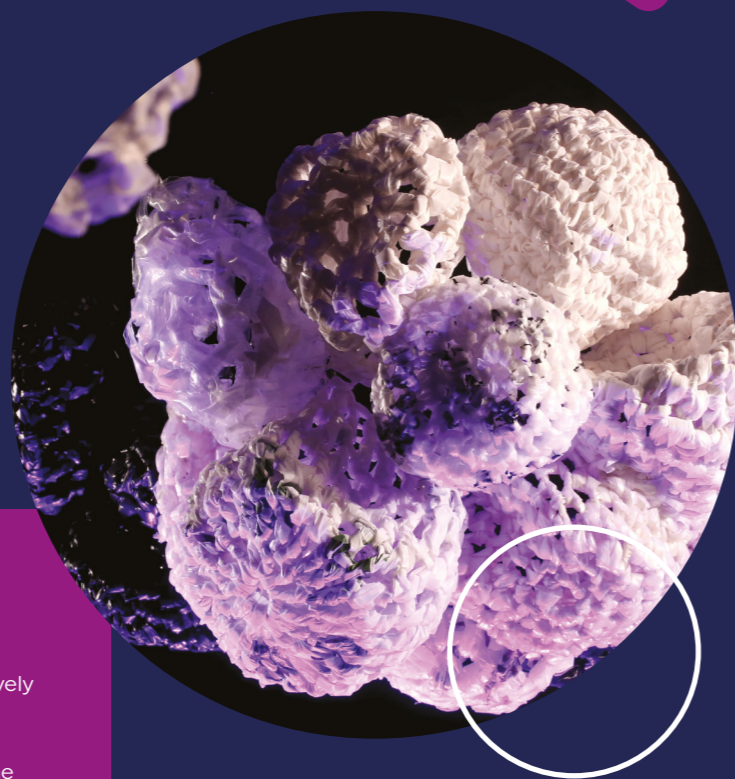
“

UNDER WHAT  
CIRCUMSTANCES DO YOU  
THINK IT IS ACCEPTABLE  
TO EXPERIMENT ON LIVE  
ORGANISMS?”

”

## HOW IT IS MADE

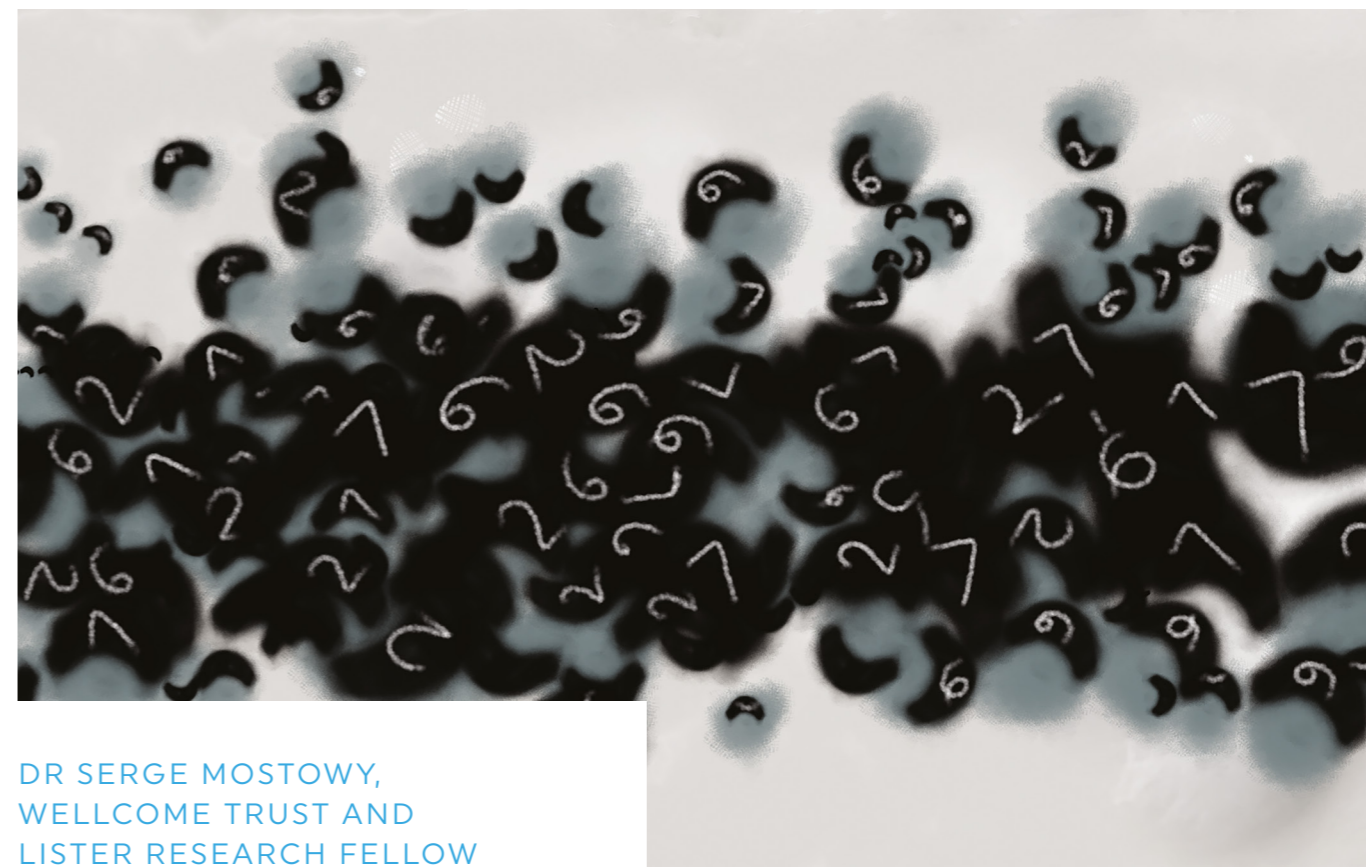
Loop is a 2D CG animation made collaboratively with the members of the Mostowy lab. The artist used a different technique to animate each section that suited the visual style of the scientists' descriptions. For example, to translate lab member Stephen Buranyi's drawing of clustering septin proteins, animator Tilley Bancroft crocheted septin proteins out of plastic yarn and made a stop motion animation.



“

SHOULD THERE  
BE MORE CONTROL  
OVER PRESCRIBING  
ANTIBIOTICS?”

”



DR SERGE MOSTOWY,  
WELLCOME TRUST AND  
LISTER RESEARCH FELLOW

BACTERIAL INFECTIONS CONTINUE  
TO CAUSE GREAT HUMAN SUFFERING  
AND DEATH THROUGHOUT THE WORLD.  
MUCH RESEARCH IS NEEDED INTO HOW  
THE PROTEINS AND CELLS WITHIN OUR  
BODY REACT TO THESE INFECTIONS.

I carry out research in vitro (that is, in artificial situations outside the body) to understand how things might work in vivo (that is, in the living body). I am particularly interested in the cytoskeleton and how it can be used in the body to fight bacterial infection. I study cytoskeleton proteins called septins that can build cages around bacterial pathogens, capturing the harmful microbes and stopping them from replicating and from invading other cells.

My work should provide vital clues and new ways for controlling and fighting infection in the body, and for counteracting antimicrobial resistance. It may also help us to understand more about diseases, like Crohn's and Parkinson's, which are caused by the body's immune system malfunctioning.

“

SHOULD SCIENTISTS MAKE MORE  
EFFORTS TO COMMUNICATE THEIR  
RESEARCH?”

”

## GLOSSARY

### TRANSGENIC:

The genome is a biological instruction manual and every living organism has its own genetic code. The content will be different for a virus than for a human, but because they are written in the same language, instructions (genes) can be copied and pasted from one manual to another. Organisms that receive a new gene from an outside source are called transgenic.

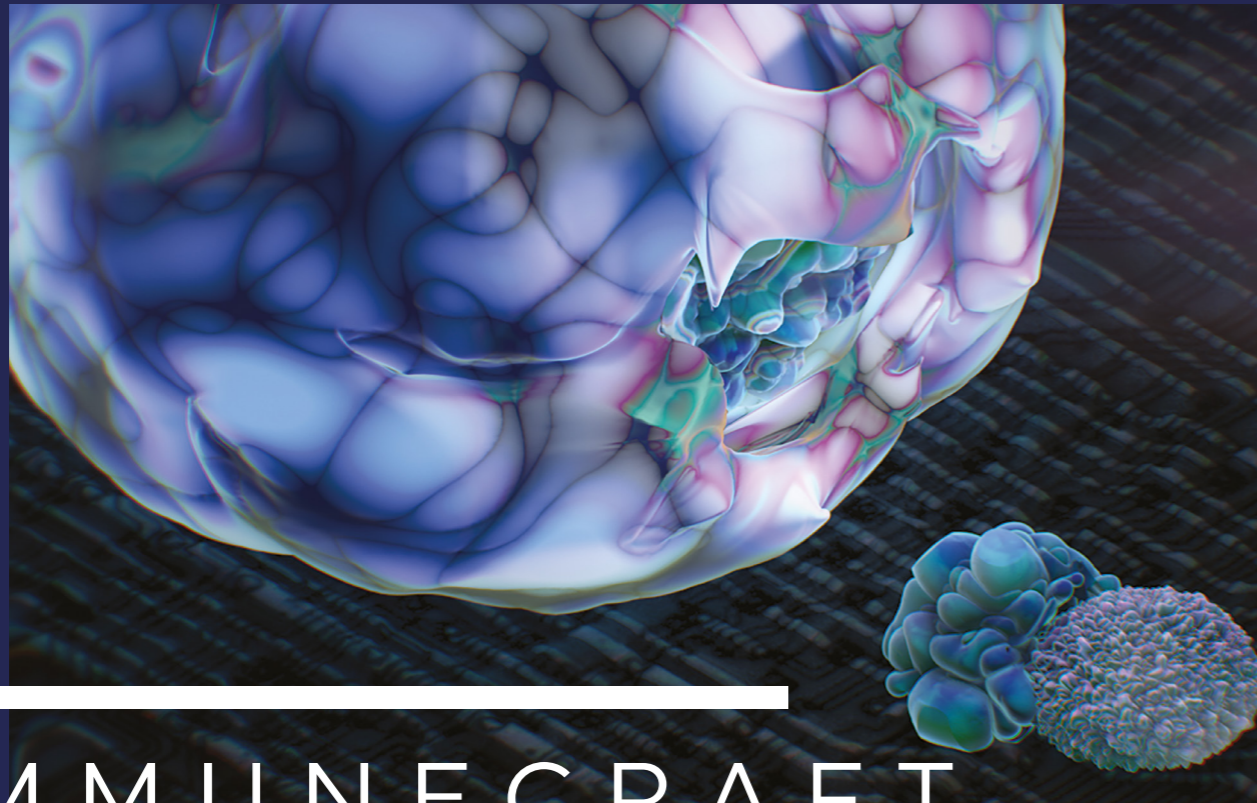
### OPTICALLY ACCESSIBLE:

Zebrafish embryos remain see-through during their development. Adding fluorescent transgenes (originally from corals and jellyfish) to cells means they can be filmed in real-time using microscopes that detect fluorescence. As data can be collected from the same animal at multiple time points, this reduces the numbers of animals that need to be used.

### AUTOPHAGY:

When your cupboards get too full they need cleaning out. By looking at the contents and deciding what is now junk, what can be recycled and what is still useful, keeps the cupboard clean and tidy. Cells also do this and continually reuse, recycle, and throw stuff out. This cellular process includes dedicated machinery which relies on the cytoskeleton, and is crucial for destroying bacteria.





# IMMUNECRAFT

ERIC SCHOCKMEL IN  
COLLABORATION WITH  
DR MEGAN MACLEOD

BIOLOGICAL INFORMATION JUST  
BECAME A COMMODITY. TO SUCCEED  
YOU WILL NEED A GOOD MEMORY AND  
SO WILL YOUR IMMUNE SYSTEM.

Computer games have rules. Characters have different abilities and roles. Some of these are automatic and never change and some are influenced by their interaction with new characters. In computer games the program is set and the rules cannot change. This is not the same for your immune system because sometimes that code can go wrong. Immunecraft uses elements of common gameplay to capture forms and functions from immune cells to give players control over their fate.

## HOW IT IS MADE

Immunecraft is a 3D CG animation that adopts the form of a video game trailer with its inclusion of menus and gameplay functionality. Colours that are found in nature, such as coral reefs and animal tissue, inspire the look of the film.

“

ARE INDIVIDUAL  
CELLS ALIVE?

”



DR MEGAN MACLEOD, RESEARCH  
FELLOW, INSTITUTE OF INFECTION,  
IMMUNITY AND INFLAMMATION,  
UNIVERSITY OF GLASGOW

THE KEY AIM OF MY RESEARCH IS TO  
UNDERSTAND A TRICKY BIOLOGICAL  
MYSTERY. HOW CAN IT BE THAT WHILE  
OUR IMMUNE SYSTEM PROTECTS US  
FROM INFECTIOUS DISEASES, IT CAN  
ALSO CAUSE HARM TO OUR OWN  
BODIES?

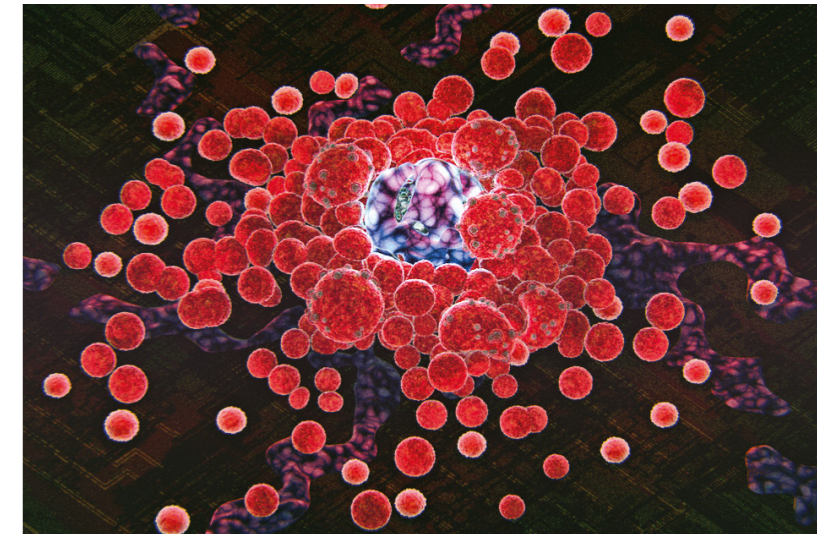
My work focuses on a particular immune cell type, CD4 T cells, which are the controllers of the immune system and who tell other cells to respond to pathogens (intruders). In autoimmune diseases, such as rheumatoid arthritis, these same cells can go wrong and instruct the body to destroy its own healthy tissues.

CD4 T cells are quick learners with great memories. Once they have been taught how to deal with an intruder, the next time they meet one, they react faster. This is how vaccines work: the CD4 T cells remember the pathogen from the small amount injected in the vaccine, and then, if the body is infected by the real thing, the cells react faster to destroy it. Unfortunately this quick learning is not so good in autoimmune diseases where the body will act faster to destroy itself.

Understanding just how CD4 T cells work is key to learning how they might be manipulated, either to make them better at fighting pathogens, or to prevent them damaging healthy tissue. I want to understand how CD4 T cells learn from their environment so we can improve vaccines for diseases such as influenza and malaria, and turn off the CD4 T cells that are destructive in autoimmunity such as rheumatoid arthritis.

SHOULD PARENTS  
BE FORCED TO  
VACCINATE THEIR  
CHILDREN?

”



“

AFTER REMOVAL FROM  
THE BODY WHO OWNS  
BIOLOGICAL MATERIAL?

”

## GLOSSARY

### IMMUNE SITES:

As well as the soldier cells that travel around the body, there are important specialised immune tissues located in specific parts of the body. These include the bone marrow that produces all the blood cells, the thymus that teaches T cells what to attack and the spleen that filters the blood and stores cells. There are other smaller sites called lymph nodes all over the body and these often get swollen when we get sick.

### CELL CULTURE:

Cells can be collected and kept alive in artificial environments. Cells are kept in specialised containers in a media that is a liquid rich in nutrients. Cells can be removed from the body and immediately used in the laboratory but they don't survive long. Cells can be altered to make them grow, divide and survive for much longer and these are called cell lines.

### SYNTHETIC BIOLOGY:

A new area of research that combines many different approaches to artificially design and engineer biological systems to improve them or make them more useful. Genetic engineering normally deals with one gene at a time while synthetic biology deals with whole organisms including programming in brand new functions.



# THE SIGNAL AND THE NOISE

CHARLIE TWEED IN COLLABORATION WITH DR DARREN LOGAN

IF A GENETIC CODE NEEDS TO BE IMPROVED, WHO WOULD MAKE A BETTER EDITOR: A HUMAN, A MACHINE, OR WOULD WE NEED A HYBRID?

You are the one of the latest 7.4 billion versions of the human genetic code currently in operation. This code not only defines us as we are now, but is also both an historical diary of our evolution, and a blueprint for our possible futures. Scientists have invented new ways to read and change genetic information, creating new opportunities and insights into biological life. In the film, anonymous hybrid voices narrate the ways in which biological and computer coding could blend together to discover how genes can be mined for new information.

## HOW IT IS MADE

The film combines 2D CG animation with appropriated material from different sources, including stock footage and research videos sourced from the Wellcome Trust Sanger Institute. The artist also shot and edited in the establishing shots of buildings. The semi-fictional narrative is voiced using a text-to-speech reader.

DR DARREN LOGAN, GROUP LEADER - WELLCOME TRUST SANGER INSTITUTE

I STUDY GENES, THE INSTRUCTIONS TO BUILD AND OPERATE OUR BODIES WRITTEN IN OUR DNA. EACH GENE CONTAINS THE CODE FOR A DIFFERENT PROTEIN, AND TOGETHER THESE MAKE UP THE BUILDING BLOCKS OF OUR CELLS AND ORGANS. IF AN ERROR OCCURS IN OUR GENES, CALLED A MUTATION, THE INSTRUCTIONS CAN BECOME MIXED UP AND LEAD TO A GENETIC DISORDER.

New DNA sequencing technology lets me read the full set of genetic instructions of any person or animal, called the genome, but understanding what each gene does in the body is not easy. I'm very interested in finding genes that are responsible for some of our basic human behaviour including fear, aggression, sex and the way we approach parenting. My research aims to reveal why we mostly act in certain predictable ways, and why unusual behaviours are found in some genetic diseases. Finding and decoding the important behavioural genes is particularly difficult, because our unique personal history (nurture) contributes as much as our genetic blueprint (nature).

So we could say that the genetic signal is quiet against all the noise of experience. That is why I have to use supercomputers to search for changes in genes across many different individuals. After I find a gene that might be involved, I investigate its instructions - typically by altering the same gene in a mouse and studying whether behaviour changes. This work contributes to our understanding of how genes and experience together result in different personalities.

“ CAN NURTURE CHANGE NATURE? ”

“ WHO OWNS THE GENETIC CODE? ”

“ WHO ELSE SHOULD HAVE ACCESS TO OUR DNA PROFILE? ”

## GLOSSARY

### CODE:

In computing there are lots of different codes. Some codes are better for certain tasks, and some codes are preferred by programmers to write in. The code is the instructions behind what you see. These can be anything from a digital animation to the barcode that lets you buy lunch. There is only one biological code, made up of only four letters - A, T, C, G - that provide the instructions to make every living thing.

### SEQUENCING:

By finding out the order of the four nucleotides, adenine (A), guanine (G), cytosine (C) and thymine (T), researchers can read the genetic code and start to learn what each bit of code does. The first human genome took 13 years and cost \$1 billion to sequence but advances in technology have made sequencing much faster and cheaper. Today a human genome can be sequenced in around a day for under \$1,000.

### CRISPR-CAS9:

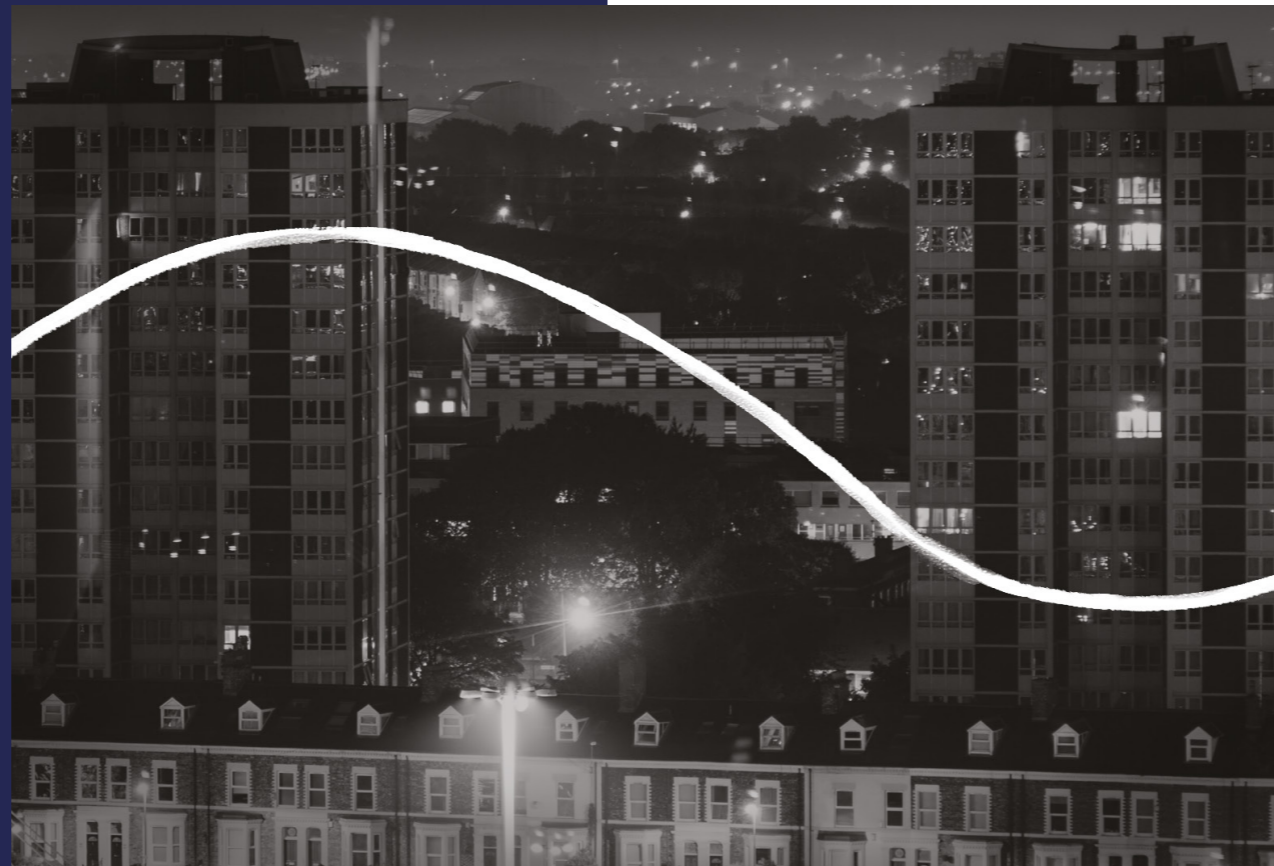
Bacteria use this ancient editing process to protect themselves by cutting up the genetic code of attacking viruses rendering them harmless. CRISPR acts as a guide that brings the tiny molecular scissors (Cas9) to a specific stretch in the genetic code to cut through it. The cell will try and stick the ends back together but can make mistakes and ruin that bit of code. By designing their own CRISPR guides, scientists can cut anywhere they want and even paste in new genes to edit the genome.

# SLEEPLESS

ELLIE LAND IN  
COLLABORATION  
WITH PROFESSOR  
PETER OLIVER

## HOW DID YOU SLEEP LAST NIGHT? HOW WILL YOU SLEEP TONIGHT?

When we sleep we are vulnerable and unproductive, and so for a long time sleep was not thought to be important. New research is changing this opinion, as the value of sleep to our physical and mental health is being discovered. While our sleep is unique to us, the effects from a disturbed night's sleep can be carried over into our waking day. Inspired by the conversations of mental health service users, this film documents how important our relationship with sleep can be.



## WHAT KEEPS YOU AWAKE AT NIGHT?

## WHAT IMPACT DOES MODERN TECHNOLOGY HAVE ON OUR SLEEP PATTERNS?

## HOW IT IS MADE

Sleepless is a 2D CG animation that combines hand drawn techniques such as lip sync animation with timelapse footage of urban and coastal landscapes. The soundtrack includes the voices of a group of mental health service users and a score produced and performed by musician Jonny Race and scientist Peter Oliver.

PETER OLIVER, ASSOCIATE  
PROFESSOR OF NEUROSCIENCE,  
DEPARTMENT OF PHYSIOLOGY,  
ANATOMY AND GENETICS,  
UNIVERSITY OF OXFORD

## "HOW DID YOU SLEEP LAST NIGHT?"

This is something that you may have been asked lots of times, but it is a very important question. We probably spend about one third of our time asleep – over your whole life that's 30 years! But we still don't really know what sleep is for. Some scientists think that sleep is very important for our brains. When we are asleep, the brain is still very active, making new connections to help us remember things for the next day and the future.

## DO WE VIEW MENTAL HEALTH DISORDERS DIFFERENTLY FROM PHYSICAL HEALTH PROBLEMS?

It is also very common for people who have illnesses that affect the brain (neurological disorders) to have problems with their sleep that make it difficult for them to live a normal life. My research aims to learn more about how the brain controls sleep. If we can identify some of the sleep mechanisms that go wrong when people are suffering from a mental health disorder it should help us to provide better care both at home and in hospitals.

## GLOSSARY

### SCN:

The Suprachiasmatic nucleus (SCN) is made up from a small group of cells in a part of the brain called the hypothalamus. It acts as the master internal clock by receiving information about light from the eyes and sending out signals throughout the body.

### GENE EXPRESSION:


When you express yourself you are sending other people information - it could be from your body language or the volume of your voice. Genes can only express themselves in one way and that is by telling a cell to make proteins. The regulation of this gene expression therefore influences the structure and function of all living things.

### MOUSE MODEL:

Mice are an excellent model for human brain studies. They have a very similar brain structure to us and their genes can be altered to mimic human neurological conditions. They are a particularly important tool for studying circadian rhythms and sleep.





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