ROADBLOCK

Notes from Science Practice

An experiment in exploring interdisciplinary biotechnology research through ethnography, design and fiction. This newspaper draws themes, images and ideas from the work of the ROADBLOCK project into a number of strange and fragmentary near-futures. We speculate on the different ways societies might take up the opportunities offered by programmable biology and engineered biofilms as well as how culture might develop in response to a new relationship with programmable biology.

Contents

Information and knowledge circulation have always been critical battlefields not only for science and technology but for human societies more generally

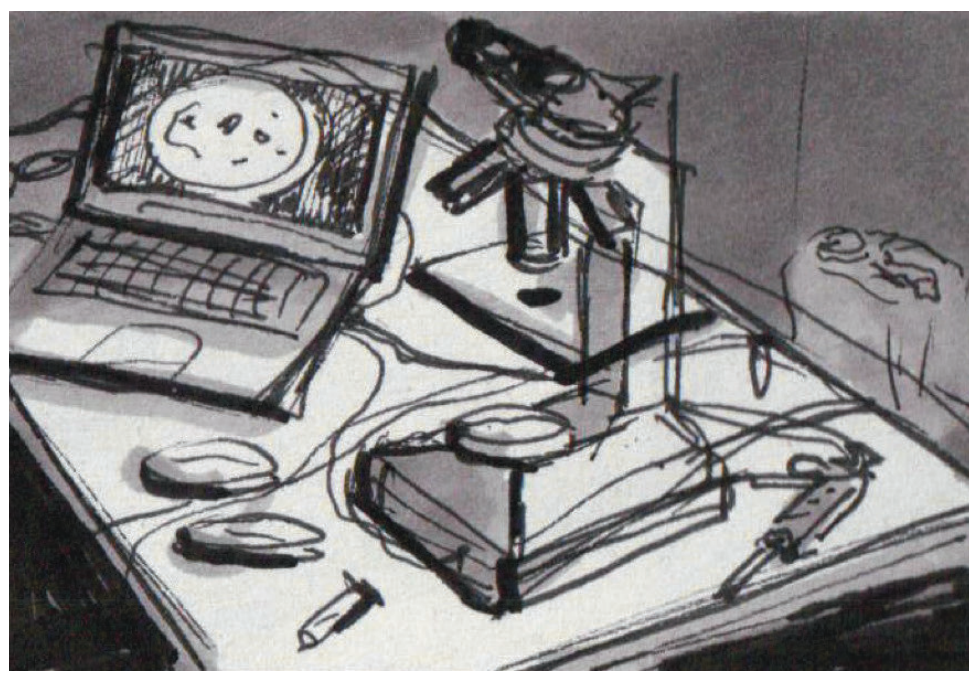
Delfanti, A. (2013). Biohackers: The politics of open science.

But it cannot be said that living things are at heart sloppy, fuzzy, inexact, and unscientific. How does an oceanic salmon find its way home to spawn on the very rivulet it left in Oregon three years earlier? How is a meter-long sequence of billions of nucleotide base-pairs reversibly coiled without entanglement into a nucleus no more than a few thousand base-pairs in diameter?... Such miracles bespeak of reproducible precision. But that precision is not the kind we know how to write equations about, not the kind we can measure to eight decimal places. It is a more flexible exactitude which evades quantifying, like the exactitude of a cell's plasma membrane dividing the universe into an inside and an outside with not even a virus-sized hole lost somewhere in all that convoluted expanse: topological exactitude, indifferent to quantitative details of shape, force, and time.

Winfree, A. T. (1987). When time breaks down: The three-dimensional dynamics of electrochemical waves and cardiac arrhythmias. Princeton, N.J: Princeton University Press. p. 253.

An idea presupposing a closed and finished world, gives way to an open world full of divergent processes yielding novel and unexpected entities, the kind of world that would not sit still long enough for us to take a snapshot of it and present it as the final truth.

DeLanda, M. (2002). Intensive Science and virtual philosophy



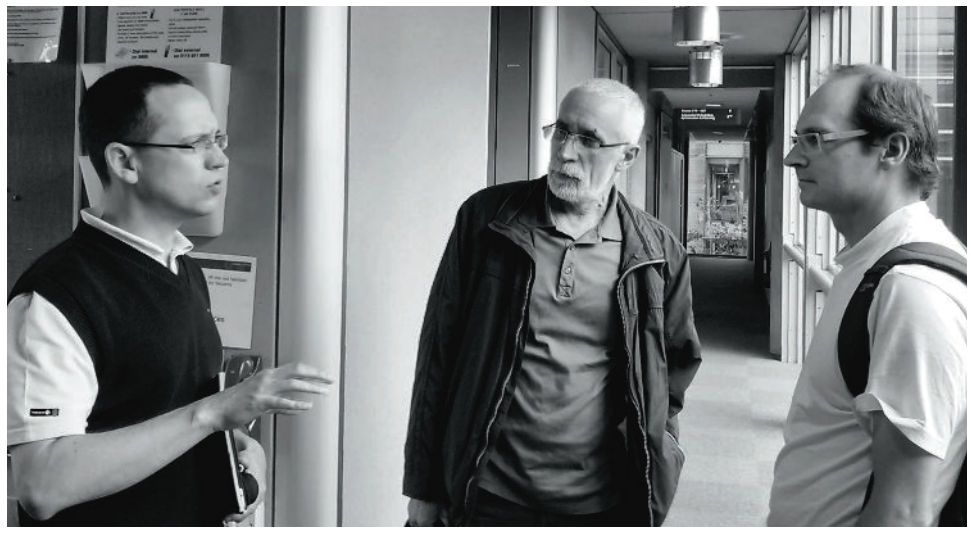
Materials

In a chemical plant you have different bits that get together. Do you understand the whole thing? No. But you understand enough about each component to do what you need to do.

We asked the biologists what they wanted and a lot of their questions were the same thing but differently expressed- just simple things mostly related to time series. What they expected to be able to ask. So instead the computer scientists gave them a wider variety of more complex questions and said 'would things be useful?' So hopefully it extends their vision. This all develops in discussion. At first they thought they would just use their data, but in fact it became a two way relationship.

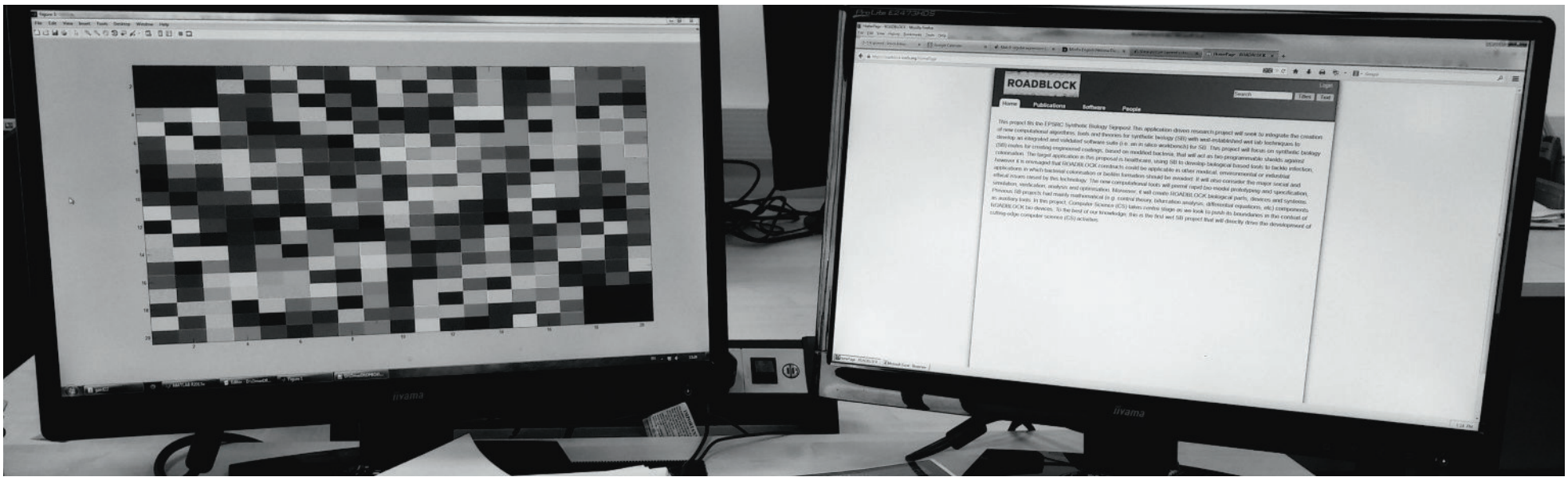
You need to be there in the lab all the time. Anything changes you need to react immediately, to adjust. It's so sensitive that you can't tell what's caused a change. When you're mixing the chemicals your mood, your concentration- it seems to have an effect. It's sensitive to temperature and to light, so the time of day, whether the lab is busy, maybe someone else has used the machine in between experiments. You have all the settings the same, but still- just a millilitre makes a huge difference.

So you do 6 replicates to compare. You never expect a 100% match. If its a perfect match it's probably wrong.



Systems biology is basically reverse engineering. What we do in synthetic biology is the opposite- start engineering form the smallest bits- the devices and parts. It's top down vs bottom up.

We have an operating cycles, where you read one after another and it forms linear memory, and under the microscope you can physically see what you have recorded. Theoretically it's getting pretty close to a Turing machine, but whether it work in the test tube is a different story.



In a population of bacteria who are all genetically identical, if you analyse at the level of individual genes you'll see that while the majority of the population has a gene switched on, a minority will have it turned off. There are **many interdependent equilibriums within cells, and there is also noise**. Noise plus equilibriums causes processes to move in one direction at the population level. **But if you look under the microscope some cells are not going with the majority.** This has an evolutionary advantage- the vast majority of these bacteria may be vulnerable to an antibiotic. So you can wipe out 99.9% of the bacteria that way, but the ones which do not have the relevant gene switched on will survive. They sleep through the whole process.

This is the end point- we need to build this part, then this part, then this. we have to test this and this and then put it in the catheter and test it there. It's a very ambitious project- so many parts- the small pieces will be polished and published. You look for parts where you see "that will make a nice story" the others can do their modelling and we can show that the construct works, "that would be a nice story for a paper."

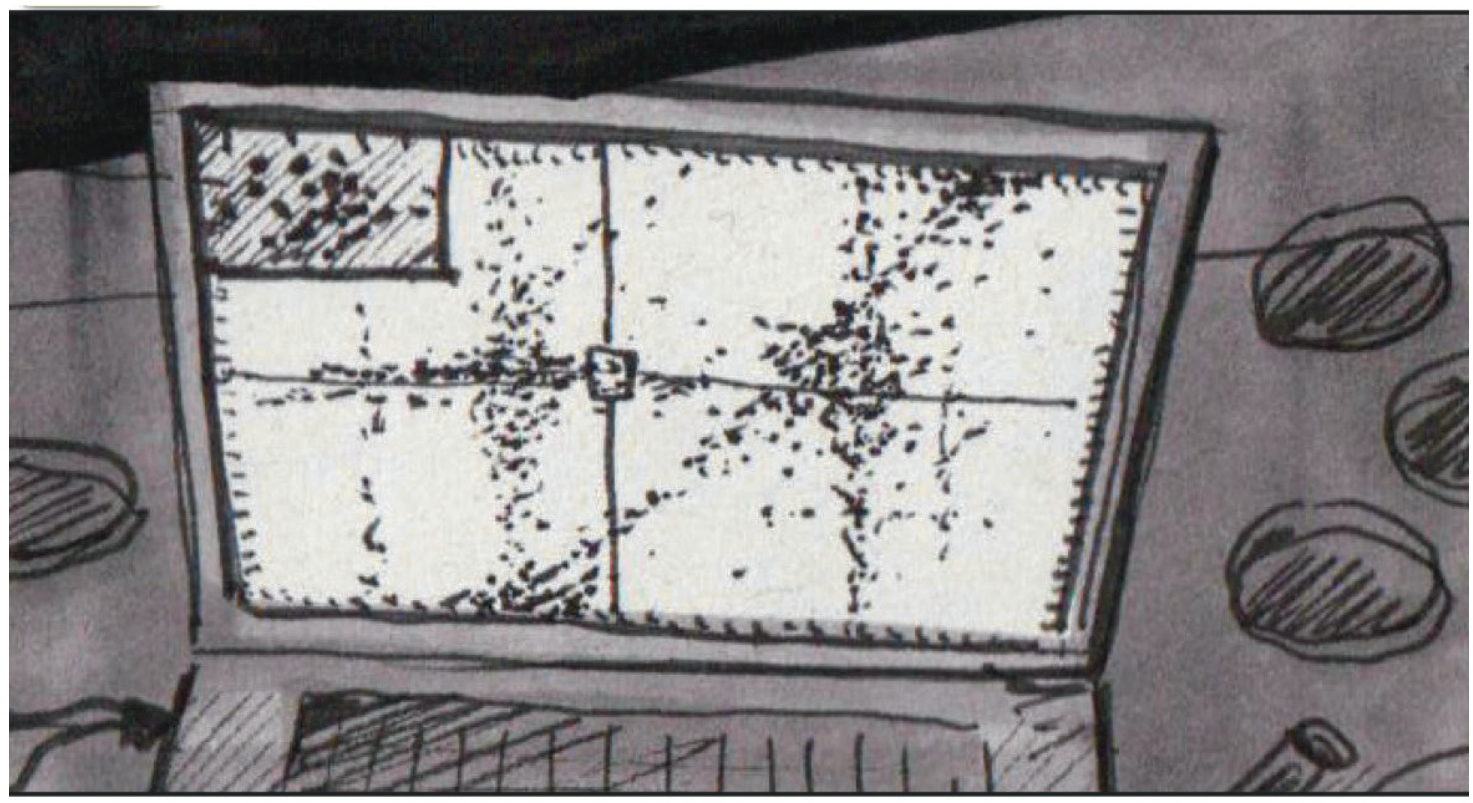
Audience Question: The resources available in academia lead us to answer certain questions: we can make 10 litres, but we have no equipment to make 100 or 1000. What are the proof points that industry needs?

Keasling: If you want to produce high volume you'll need a higher proof point. Berkley has a scale-up facility that helps academics move to new volumes.

Clarke: Within industries there are different structures. It is always worth remembering you work with individuals, not a corporate entity. It comes down to engagement with the people who are seeing your offer as part of the solution to their problem.

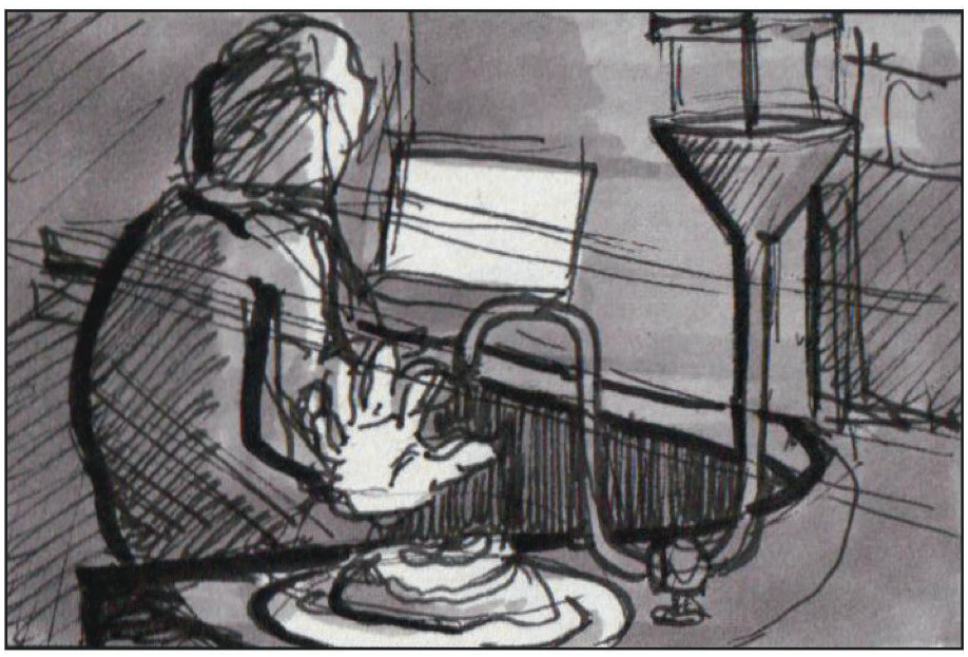
Clarke, L., Laderman, S., Shetty, R., Keasling, J., & Martins dos Santos, V. (2013, July). Translating Technology, Transcending Industrialisation, In R. Kitney (Moderator), SB6.0: The Sixth International Meeting on Synthetic Biology London, UK.

The projects involved seventeen interviews with the roadblock team and their colleagues, and many more conversations and meetings



He explains “Its encrypted, but with enough effort any message can be decrypted. We share keys- share the original genetic code online and grow your own decrypter or if you’re really paranoid you can grow a decrypter yourself, split the batches- one for you, one for the reader- and never write it down. Then the two separate strains they evolve separately. So the key , the connection breaks down. This one is from a really old pairing—Looks like nonsense— to any spy it *is* nonsense. But I know the conditions it was in, and how that encouraged it to evolve certain features which distort the message in certain ways. So I can work back, reverse engineer and make more sense of the original. ”

Entangled Systems



....takes a protein cake.
Conversation in basic IRC window which hovers over the controls for his food printer setup.

She thinks I suck at caring for the home farm, can't understand why my sensors keep glitching, the support system failing and the microbes stubbornly refuse to thrive and produce. She offers advice and reassurances and apologies, links to tutorials, to alternative stocks, nutrient mixes, light cycles, model files to print extra kit, even different plastics to feed into my printer. But it's the rich chatter in between that feeds me. The little references, the old jokes and nicknames, the familiar shapes and twists of our conversations. I nurture them like I should those algae mats. Like I should have done the first time round, when there was still a chance. So yes. I suck at caring. She knows that of course. It's just another performance of the same tired routine of lost signals, hidden patterns.

Setting the Sewers Alive

northbaywanderer, Rock Violets, https://flic.kr/p/azgf8

It reached up out of the kitchen sink plughole like a wet, withered finger; a brown twist of oil-slick membranes coiled in a crooked gesture of beckoning. I left the house under a cloudy dawn, red fractures spreading through the grey sky. People would wake and something would begin. Too soon to know quite what, but I couldn't help a hot surge of hope.

It'd been a long summer; dry air, dry ground, light salads, light showers. We didn't notice we were starving our living sewers. They were new then. People rarely thought of them and if they did it was as a utility. Just another machine that happened to be slimier than a train or phone or factory.

But I was a sewage worker that summer. When I applied there was a huge spiel about the most ambitious synthetic biological infrastructure integration ever attempted, how we were, despite the appearance of our pay checks, essentially explorer-astronaut-pioneers. What they really wanted was tall, tough, brutes without gag reflexes. I expected to spend months up to my chest in effluent. It had been a bad year for me. I'd been lied to, suffered losses, was choking on my own bitter bile. The upper world of bright clean streets and shining glass felt fake. Hours to philosophise to myself in the stinking dark and retching on the job was a welcome perk. I didn't expect to be opened up, turned inside out, to find new forms of community inside and around me. You tend not to in contract labour.

Over winter they'd painted the walls of the city's sewers with colonies of synthetic microbes. Throughout spring they'd established a rich, artificial ecosystem. By summer the bugs were tasting our waste water for chemical traces and pouring out new signals for our equipment to detect. Infections, diets, blockages, toxins; the water was full of stories. I dipped the little sampler device in it and read them all. People's lives and bodies in numbers rising and falling on a waterproof screen. Which digit was her? Which was him? All of it aggregated, quantified, sent back to base.

We were mostly there to carry samplers and dip them when prompted. It wouldn't have changed the world. Except that we were also to look at the walls, where the bugs had been designed to provide visual feedback, for "common-sense validation" and "colony diversity management". Another analytical tool. Just a fail-safe.

So the sewer walls were covered in colours. Such colours. Thin trails of purple where pathogens were detected to be carefully tracked to their source by torchlight. Soft shimmering greys that nibbled at gentler washing liquids. Vivid luminescent strains that could cover the walls for solid meters metabolising whatever brutal toxin had poisoned its cousins. A whole range of healthy greens, announcing that the foul matter passing by would be happily digested by the vats at the end of the line. Amber and orange blossoming in response to fats and sugars. As I walked home each evening I swear I could recognise from the shapes of the bodies of people leaving houses when I was on top of a street that I'd been under hours before. I knew which kebab shops were pouring their left-over grease into the roadside drain, which schools were feeding their pupils scraps, which houses held sickness or addiction or celebration.

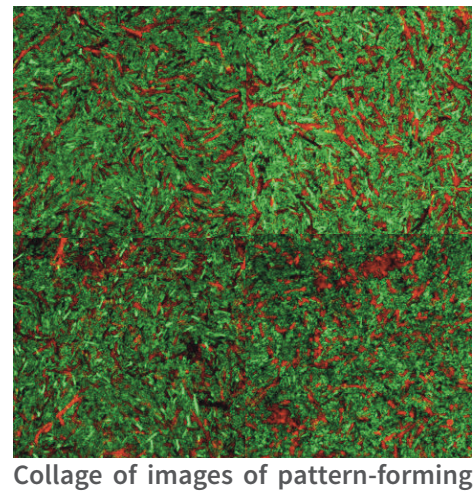
Łukasz Lech, San Francisco Sewers Crew, https://flic.kr/p/7KPFUx

I saw the world in those walls. Miniature forests speckled with blossoms and scars. Whole communities burned away by one person's careless thought. Destruction, connections, regrowth.

There wasn't any function in the sampler to report a growing sense of unease, to say that whilst we were only sewage workers and this was only the first summer of the project and we couldn't be exactly sure why, something was very wrong. The biofilm had gradually thinned, colonies eroded. Gases built up in crevices, then exploded out like a fart that would end the world. The outside world ignored the tremors. Politely. Like a stomach gurgle as you hold each other. Unwelcome evidence that despite all our poems and spreadsheets humans are essentially a big soft pipe. We ignore the long, wet conversation with the world that had always run right through our bodies and was now under our feet.

So no one expected the fingers. Overnight the colonies formed membranes and forced themselves up and out of every opening they could find- every drain, sink, shower, toilet, dishwasher and tap, like a stomach spilling out of a wound. The sticky films twisted and dried to look like browned claws. People panicked. People were disgusted, horrified, violated. There were articles, official announcements. For the first time my friends wanted to hear about my day job.

People poured bleach on them, scrubbed at them, flooded or flushed at them. The strange thing was that pouring liquids on those withered coils brought out their colours. Scrubbing smeared those colours across surfaces. People took photos. Instagram, Facebook, twitter all covered in images, a kaleidoscope of disgust, curiosity, excitement. "Cancel the holiday- there's a rainforest right under my sink", "haven't seen these colours since I quit partying!" People got excited, curious, even proud. Those living colours spoke louder than a thousand pages on the long term effects of this chemical or that on our bodies or the world.



Collage of images of pattern-forming bacteria from Bridget Koch

I was right to hope. The manhole covers are glass now, so everyone can see the colours underneath the street. There are tours in my sewers. The microbes are inside and around us. They remind us that is no 'away' for things to be thrown into. Nothing can be completely lost, unconnected. We're not just careful now, we're caring. We're all sewage workers now.

The Man with a Billion Bandmates

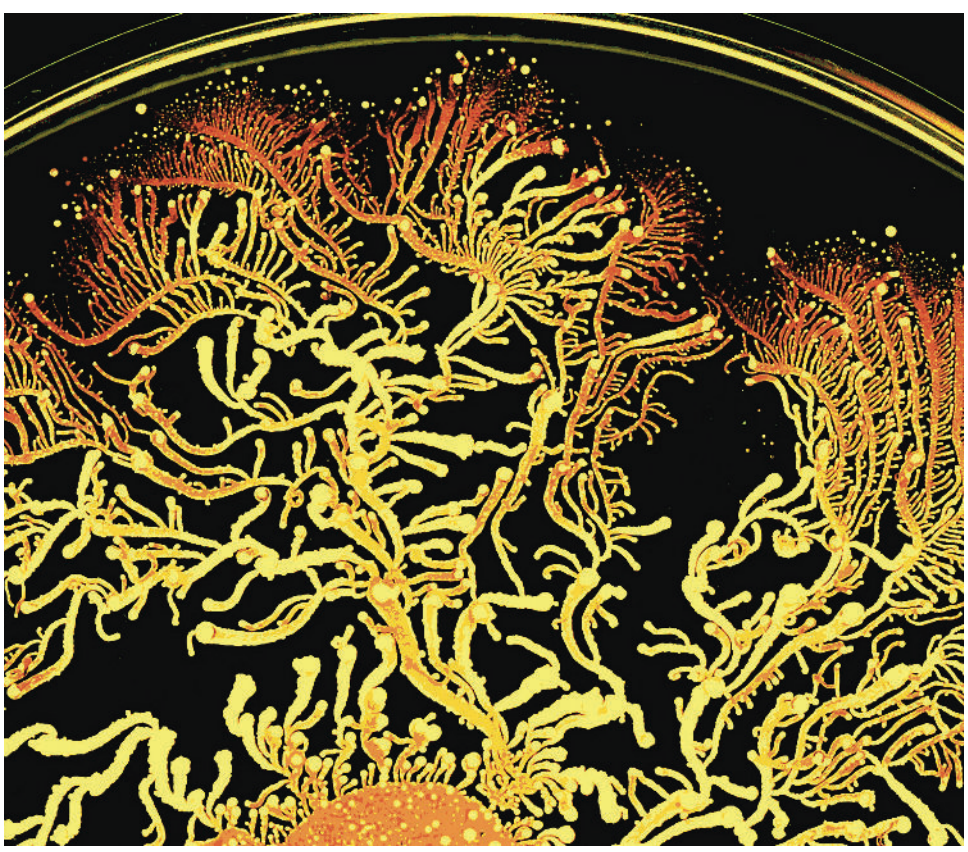
Sellula is the face of underground music scene Slimecore, which warps good old-fashioned circuit-bending around a set of microscopic partners. You thought the algo- movement was the biggest music mind bender around since king algorithm-writer Tank was knifed for fooling fans with his auto-generated death metal? Machines are over guys. Slimecore is a mess of wires, gunge, and code that will get you locked up just for listening. Tune in for technical details of why this stuff sends the kids and enforcement officers wild. Just don't swallow the DJs: they'll give you a nasty cough.

Sellula, can you tell us Slimecore actually is?
The greatest art in the history of humanity! Nah, well, it's something special. You get a set of electrodes in a dish - that's a petri dish- you grow simple living things than can carry a current on them. Usually microbes. They react, in realtime right there in the club, to the vibrations, the sweat and the sound, the mood, the stuff you feed them, the colours, the light. It introduces an unknown. You surrender some control over the music to those bugs. You have to work with them, follow them and lead them all at once.Some people use neurones, and some of those claim they use human. Sure it's even more illegal but I think it's less exciting. I get a kick out of partnering with my most distant cousins-getting the band back together after 4 billion years or so.

Right. So what does this microbe music sound like?
It's not one kind of sound. Most of it's rave stuff now, because the method's pushed underground, and that style's what works in those venues. It's a way of playing with what you love: one day we'll get SlimeFolk, SlimeClassical. So Slimecore sounds like what you love but better or stranger or both. One time I was at this huge, hyperactive rave, I wanted to feed the frenzy, do something frantic, but the microbes were just slowing everything down, I still don't understand how. So I poured in deep thunking bass and it was coming out in these enormous trembling roars. One bass line was coming out so deep it was inaudible- the sound waves physically made my skin crawl: like the air was dancing with us. The energy in the room was insane. I would never have made that on my own. I wouldn't have *imagined* that on my own.

On other days it's less dramatic, more like a kid tugging at your style, stretching it, pulling you a bit further, forcing you to keep concentrating and adapting. As an artist it's easy, once you've achieved a certain level of success or skill, to get comfortable. You think you know all you need to know. Its enough. You settle. But these little guys will mess you up. Introduce the bugs and everything becomes unfinished. I hope our relationship is always this dysfunctional so there's always something to fix, to improve.

Very sweet. How does your relationship with thousands of microscopic musicians manifest?



P. vortex colony, Prof. Ben-Jacob's lab, Tel-Aviv University

It's electricity, baby! Life carries a current. We're basically circuit bending with some extra loops, putting their quivery little jelly bodies in the mix. Signal runs through a bunch of mixing desks, tools, arduinos, through the dishes, then into amps. Some sensors and programming and sanity-checking but as much as possible what happens to the signal is a direct reaction to my touch or the microbes' activity. I've hacked together so many systems that I couldn't explain exactly how everything affects everything else, I just work with the result.
There's some standard kit- dishes with electrodes in, some microbes living there. When you want to get into the scene you could just use the bugs from your gut, and drop chemical signals in there, but most of them are synthetic. I've programmed and evolved my own strains to react to different kinds of light in ways that make them more or less able to carry a signal. So I'm putting on a light show too. Value for money. Sometimes they pick up a bit of the club's own lights too. Everything is connected.

What are you doing during a typical gig?
I'm twiddling knobs, sliding sliders, watching sensors, listening. I'll be adjusting lights, monitoring the health and happiness of my little bug buddies using a beautiful biOx plugin called shaper, which displays stats as these shapes whose angles and colours change. People think it's just a pretty visualisation, and I had it up for a few months just for the punters to see, but actually I now find it easier to process than a wall of numbers. I keep the wall of numbers up mostly to impress the punters!

So why the anger in the press? Why the arrests?
They say we're being frivolous with the stuff of life. Like in medical stuff, or in industry it's fine, but music is not serious enough. You need a license. Some of us have licenses, some of us don't. I can't get one because I got arrested on a protest march once. Plaguedream, one of the hottest artists out there, can't get a license because she shoplifted at 11 years old. A lot of us are activists or outsiders- we're not the kind of people who are supposed to have access to this stuff. We're not the kind of people who are supposed to have knowledge. They believe our creativity is only destructive- that we're going to make diseases, monsters, drugs.

They *say* it's because we're messing around with stuff that we shouldn't- but the big corporate labs, the insurance companies, the government, all of those groups have always had the keys to the microbes and the insides of our cells. Why is that profitable experimentation not 'messing'? Why should they get access, get to make things, leaving our only choice as what to buy, what licensed sounds or ideas to entertain ourselves with? Understanding is power. By making music with my microbes and machines, I'm finding out new things about the world. I'm discovering something with my audience. That's what scares them.

Medical Information

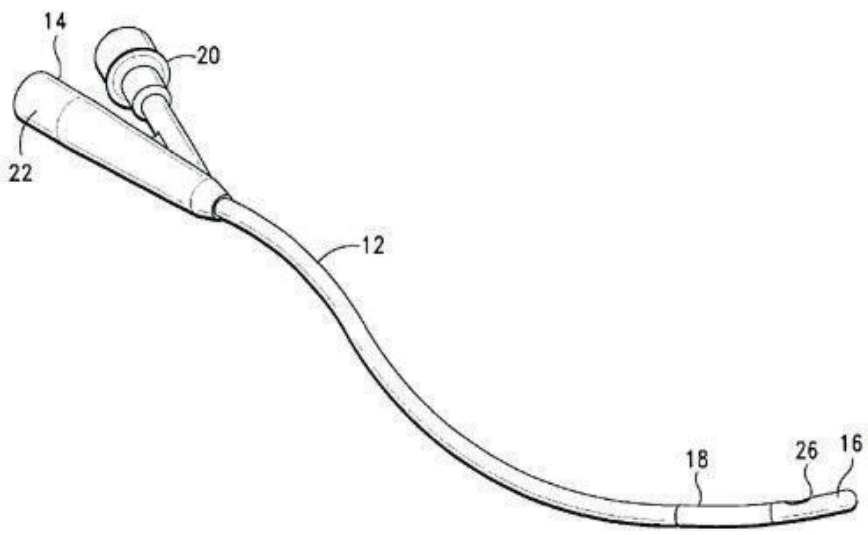
Interviews with medical practitioners about the biofilm catheter

Here at the Biomed Blog we've been thrilled to follow the progress of Guardian Surfaces on its journey through the various hoops of animal and human medical trials, approval and funding.

Over recent years more and more of the strategies we relied on to prevent and fight bacterial infection have been rendered ineffective. Multiply-resistant strains are regularly found in hospitals and care homes. Fighting infection is consuming more and more of our resources and rendering surgeries, hospital care, childbirth and elderly care more and more dangerous and difficult.

We need to adapt to a new, more flexible and pro-active approach to managing infection. Guardian Surfaces may be one of the weapons which help us turn the tide.

Guardian Surfaces detect the presence of *P. aeruginosa,* turn bright purple as a signal for healthcare workers and begin the fight against this multiply-resistent pathogen. The first Guardian Surface product on the hospital shelves is urinary catheters, and we caught up with four healthcare professionals doctors for their feedback on this new weapon in the increasingly complex battle against bacterial infection.



Foley Catheter

The General Ward

Where do you work?
I carry an average of 15-20 patients throughout the hospital and I'm responsible for their acute care and coordinating their discharges. Although the use of urinary catheters (the "foley") has been cut down significantly because of infection risk, it's still a necessary evil, and used in about a quarter of my patients. Our academic hospital is trying to be a leader in cutting down on healthcare associated risks and this product aligns well with that goal.

How did patients react?
When I explain the details of the biofilm the patient is often confused. Rather than an "eww" factor, there is more bewilderment. I explain to patients that we all have inherent bacteria on and in our bodies that we live with on a daily basis. This product happens to have good bacteria, similar to the concept of good bacteria in our gut. It's a gatekeeper, detecting intruders, which helps us ward off infection. Most of them understand.

How have other health professionals reacted?
Positively. Use of a traditional foley catheter was never considered to be a sterile process. It serves as a risk for the introduction of foreign bacteria, which is why a better process is necessary.

Any surprises so far?
We found in one case that there had been bladder colonisation in a patient exposed to the biofilm. She did not develop a UTI, but after the catheter removal subsequent urinalyses and urine cultures were coming back positive for E. coli. Turned out they were from the biofilm. This is listed as a rare side effect, but still surprised us. It did not last long but while there it may have helped protect against more serious infection. We are already used to interfering with gut flora, and I wonder if intentional colonisation is a logical next step.

The Oncologist

Where do you work?
I work as a Consultant Oncologist. I specialize in gynaecological and prostate cancer and so the main use of this product is in my prostate patients, however I also deal a fair amount with patients whose spinal cord has been affected by their cancer and who therefore have become incontinent or developed urinary retention.

What was your initial reaction to Guardian Surfaces?
Urinary infection can be a serious problem in prostate patients requiring long-term catheters. The main problem I can see this helping solve is identifying urine infections in outpatients attending for daily radiotherapy who would normally not get seen by anyone while at home.

I need to sometimes use catheters in gynecological patients undergoing radiotherapy towards the later stages, when the skin side effects become severe and when urinating can be very painful, but I'm hesitant to use this product as I'm worried about an increased risk of the bacteria entering the bloodstream when there are many areas of broken skin.

How did patients react?
It was fairly easy to explain because most patients are familiar with the thinking behind using inactivated organisms to produce vaccines. Prostate patients as well tend to be pleasant elderly gentleman who aren't put off by very much, have experienced life's knocks and are happy to get on with things and be practical about their treatments.

I explained that the majority of catheterized patients will at some point have their catheter colonised by bacteria, but that the product tried to reduce the growth of the bacteria most likely to cause problems. When it turned purple, I explained that this would be a sign that the bacteria that had taken hold was one that we would need to take seriously and that if treatment was delayed it may be very difficult to remove.

Unfortunately, a number of patients expressed concerns which could be linked back to a tabloid article which badly mischaracterised the nature of these bacteria. Most coverage has been enthusiastic, so I hope the anxiety abates over time.

Any problems?
For the most part it works very well. We had a false positive and the catheter had been changed by the time the formal laboratory results came back. I had to apologise to the patient but they were understanding that we had tried to be cautious. The treatment for pseudomas isn't particularly dangerous so no actual harm was done. I am very frustrated at the number of junior doctors who have carried out unnecessary, sometimes difficult, catheter changes out of hours because there was some uncertainty over colour change.

The ICU

Where do you work?
I'm an intensive care doctor working in a hospital that's part of a research network. There are research facilities in the hospital and we have a lot of ongoing trials. So we're used to seeing new technology move all the way 'from bench to bedside' as the saying goes.

Every patient on our intensive care unit (ICU) is very sick and has loads of tubes going in and out of them. They've often had major surgery, experienced severe trauma or have a rare or complicated disease and the ICU is the only place for them to get the treatment they need to stay alive. But it's also an extremely dangerous place for them. There are a lot of multiply resistant bacteria here. MRSA and Pseudomonas aeruginosa most commonly. The patients are sitting ducks, playing a horrific game of waiting for our supportive treatments (dialysis, ventilation, cooling, bypass) to do their work before they contract an infection just from their environment. All the patients have catheters so UTIs are particularly easy to contract.

What were your worries about the product?
I'll admit I had some concerns at first, working with living bacteria. No doctor is going to be happy to use something that you think might be dangerous if it got out. But it's been through a lot of tests now regarding just that issue, and

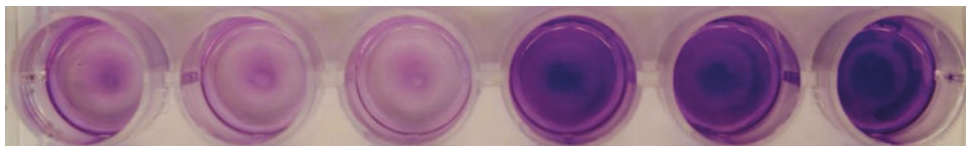
I would say I'm confident trusting the MHRA (Medicines and Healthcare products Regulatory Agency). I was particularly concerned about immunocompromised patients, but many medications are known to be risky for them and as doctors we have make a risk / benefit decision.

Did patients express any worries?
Many of my patients are unconscious, but we explain to the family. They're aware that intensive care is dangerous and their loved one is very sick, and are generally happy to hear about anything that might help. As for the live bacterial element, they don't really have any problems at all- in fact the problem can be the opposite, where they thing the Guardian catheter can solve everything. Over recent years biologic treatments have become more and more common. People take pills with live gut flora to alter and improve digestion, or mood and behaviour. We have a lot of evidence that flora has an affect on those things, but it can get twisted in health fads- they think the latest flora or biologic treatment has super powers.

Did other health professionals express concerns?
Not particularly. We've been inserting increasingly more sophisticated film covered catheters and implants into patients for decades now, while also prescribing more personalised and biologic drugs, which seem to get more sophisticated every week. This isn't coming out of nowhere.
The first reactions to growing bacterial resistance were to emphasise sterility and cleanliness. But our approach is more nuanced now. Our decisions are more along the lines of risk management (is it a pathogen or a therapy) than "ooh bacteria = dirty".

How easy to use is the catheter?
It's great, its simple. Purple catheter, treat for Pseudomonas. So much quicker than lab tests. We did have a false positive patient, but the treatment for pseudomas isn't particularly dangerous in other ways so, no actual harm was done. In this environment we have comatose patients in a high tech strictly controlled environment - we can have access to PCR and other tests pretty quickly, so the benefit of a patient might look small, but every second can count.

I'm really hoping we can have something similar soon on the endotracheal tubes for patients who are on mechanical ventilation. Ventilator-associated pneumonia (VAP) is a frequent issue in the ICU setting and early detection is key.



The General Ward & Lower-Income Countries

Where do you work?
I'm currently in a general ward having recently returned from a placement abroad with Medicine Sans Frontières. In my current hospital we're understaffed so there's very little time for the patients and because so many of them have English as a second language explaining procedures can be difficult. Of course those problems are nothing compared to the hospitals I've worked in outside the 'first world', where power cuts and shortages were common.

What was your initial reaction to Guardian Surfaces?
It doesn't seem to be practical for the more challenging environments I've worked in. Hospitals without reliable infrastructure suffer power cuts so temperature can vary wildly. Deliveries of new medicines are infrequent and have often travelled a long way in bad conditions. A medication or tool that can't sit on the shelf for months, if not years in tough conditions isn't worth it. Catheters are usually bought in bulk and sit in the supply room a long time, so the limited shelf life is a problem. In the UK those issues are manageable, although it is competing against much cheaper products.

How did patients react?
It's complicated by difficulties in communication. A few refused based on the 'anything with e.coli is bad' principle. One told me 'E. coli is found in faeces, so it's contaminated'. It may not be logical, but the hospital experience is already quite frightening and the walls are covered in posters talking about *fighting* E.coli. One woman got very upset when the catheter turned purple. The signal meant we caught and treated the infection quickly, but she was still stressed by the experience.

How have other health professionals reacted?
Sirens go off in my head when I hear it. In women, it would be really awful to give someone pelvic inflammatory disease because you've directly introduced E. coli into their body. It feels sort of counter intuitive.
But then again, as I said, infection is a problem we're all worried about. Any plastic product used in long term for patients is a potential source of infection, such as IV lines, tracheostomy tubes, NGO tubes, etc. It's always a complicated decision.

How easy to use is the catheter?
When you're checking a large, busy ward while in a rush/on ward rounds/in the middle of the night and are absolutely exhausted the bright purple is a nice vivid signal with an obvious next step.

The Care Home

Where do you work?
I'm a nurse practitioner in a nursing home caring for a hundred and fifty residents who are mostly in their 80s and 90s. Most of our residents are state-funded and the suburb we're in isn't the wealthiest, but we have an official rating of 'good' care, with 'excellent' in some categories which we worked hard for. There are about eight care assistants for every qualified nurse here. They're fantastic, and they're great at letting me know when something seems to be amiss with a resident, but there are a lot of decisions and procedures which they aren't qualified or permitted to assist in. The industry trend has been to more and more carers and fewer nurses, as of course we cost more, so I'm stretched rather thinly across a lot of residents. I have a lot of different responsibilities, such as managing their medications, feeding tubes, oxygen tubes and of course the catheters.

Infection is a horror here. Our residents are frail, often immunocompromised, on multiple medications. Many have conditions which make it difficult or painful to move, and many more are incontinent. On top of that many have conditions such as early stage dementia which make it harder to understand and inform us when something is wrong, and others are on very strong pain medication for other conditions. So we can't rely on them to tell us when they have an infection.

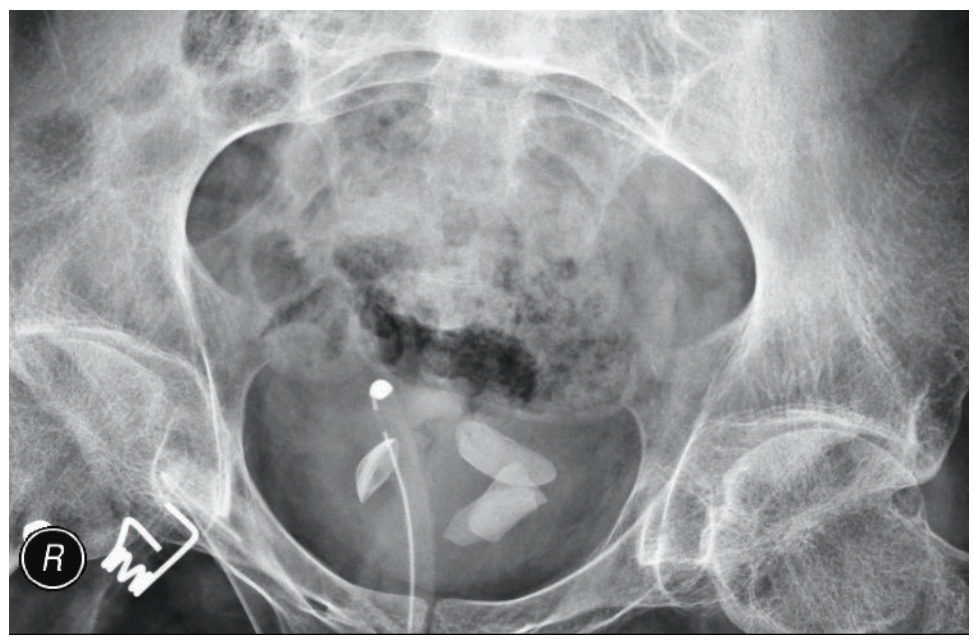
It's hard to control the environment completely- this isn't a hospital ward. Patients who are very sick still want to do gardening, or to visit a park. When their family visit they want to hug and kiss them. The place isn't sterile. We also have limited access to tests and treatments. The GP is often here, and residents visit hospital specialists, but it all takes time to access and our residents can go into steep decline very quickly.

Simply put we are in a constant, losing battle with infection in those tubes.

What was your initial reaction to Guardian Surfaces?
This stuff should be in every tube. Its fantastic. The care assistants can immediately tell me that a tube has turned purple. That prompts immediate removal of the catheter, and as the biofilm fights the infection before that, we can often prevent an infection before it even got started, which is a life-saver for residents whose own defences are so frail.

I can't wait until we can have this in the feeding tubes, and oxygen tubes. I'd love to have something similar on cannulas although as there is contact with the bloodstream it could be too risky for a live bacteria.

One concern I still have is for those residents with dementia. If an episode of acute confusion leads to the patient pulling out their catheter, balloon still inflated (unfortunately a frequent occurrence) this leads to significant trauma, which can expose the patient bloodstream directly to the bacteria.



© Nevit Dilmen. X-Ray showing catheter placement and bladder stones

Value and Validity

“The organisms aren't like 1+1: there might be fluctuations." In an all-hands meeting of a multidisciplinary multisite synthetic biology project a wet-lab biologist is answering his computer scientist collaborators' requests for data. The computer scientists require data in order to test and improve their model. But the wet-lab biologist does not wish to provide preliminary data until experiments have been replicated sufficient times. The incomplete computer model and unfinished biological experiment are not equivalent or compatible. Whilst data can and does flow readily between scientific disciplines, in interdisciplinary work this interaction can occur at very early stages of work, revealing the unstable forms that information takes on its way to being validated through processes such as peer review. Differences between the two disciplines’ traditional methods of producing and validating information require careful compromise, attention to practical matters of scheduling and communicating, as well as more abstract consideration of when and how data becomes worthy of sharing. Negotiating the interaction of different forms of information is one of the key challenges of contemporary multidisciplinary biotechnological projects. This negotiation of value and validity of information forms takes place in the context of what Sunder Rajan calls “the convergence of the life sciences with systems and regimes of capital" or “embracing of market logics” as the science is ever more entangled in market forces and private investment.

Multidisciplinary projects are increasingly common in western biotechnology, in fact Fischer says it is "the catchphrase" of early twenty-first century American medical funding. He notes that multidisciplinarity is useful for opening up new spaces for established institutions to "mediate competing demands" (2012:414) between separate disciplines and their representative administrative departments. Information flows into the life sciences in wildly different forms- the blue/purple tint of racks of petrie dishes in a resazurin viability assay, smooth graphed curve of modelled zeta potentials of cell surfaces or the averaged result of a hundred thousand modelled operations of a cellular process. Multidisciplinary projects require that different disciplines open their black boxes and negotiate new collaborative models of work within unmapped spaces. Their different information forms must be rendered interoperable during design and development stages- well before the process of peer review which has for so long provided a cross-discipline benchmark of scientific validity.

Synthetic biology is a relatively new field within biotechnology in which "a new engineering approach to bioscience"(Ginsberg, A. D., Calvert, J., Schyfter 2014:iv) produces "the design and construction of new biological parts, devices, and systems" (Silver 2009) for the creation of "‘interesting’, ‘useful’, and above all, ‘industrialisable’ biological ‘products’"(Finlay 2013). Synthetic biology attracts practitioners from a variety of fields- Finlay records that her informants included "biochemistry, microbiology, molecular biology, bioinformatics, biotechnology and structural biology on the ‘biology side’ and from chemical engineering, electrical engineering, biomedical engineering and mathematics on the ‘engineering side’" (2013: 28). Those I interviewed had similarly diverse backgrounds, with an additional subset of the computer scientists specialised in modelling.

Because Synthetic Biology is a meeting point for many different methods and cultures it offers a lot of opportunities to observe what Fisher calls 'translations’, where information must change form, or adapt to a new context. For instance information and ideas must move from the lab through testing equipment, databases and models, into reports, publications and funding application. Fisher describes “gear shifts between macro-, molecular, and nanoworlds (among proteins, enzymes, polymers, and cells), shifts and differences between in vitro and in vivo environments, and among experimental systems" or those translations "that occur between fields of expertise.” Points of translation can bring hidden assumptions and habits to light, and thus are very productive points for investigating "the series of transformations that medicine and the life sciences are undergoing" (2012: 386).

Helmreich defines the term "biocapital" as the interweaving of the "substances and promises of biological materials" with profit-making (2008:463). He explains that alongside the economic capital of profit-making biocapital connects other forms of capital such as cultural capital and social capital. Valuing biological materials and the promises they offer is made even more complex by the frequency by which they are 'translated'. Different participants within biotechnological projects may have very different histories and value systems, different immediate and long-term goals and so may value examples of "biocapital" very differently. Sunder Rajan is particularly interested in investigating how value changes as information moves through various translations- exploring "where the value resides as biology becomes an information science, and what work and whose agencies are required to create these values" (2006). Essentially- who places what kind of value on information, and whose valuation carries the most weight.

The influence of capitalist affordances on 'value' for scientists in emerging biotechnology fields does not just affect economic capital, or profit. Finlay notes in her ethnography of synthetic biologists that the centre where her informants' worked was "well funded"(2012:28). Rather than money they desired "instruments, expertise, space and credibility"(1986:216) which Latour and Woolgar identified as forms of capital which correspond to advancement in the scientific "credibility cycle" (1986:217).

Investigating the flow of influences as "capitalist practices see university and corporate biosciences becoming porous to one another"(Helmreich 2008:464) is not a question of simply following the money. Sunder Rajan accepts this complexity, but claims it is still "analytically important to not abandon the question of determination" (2012:9). He uses Žižek's concept of "overdetermination" to explain how market logics influence the system even when profit is not the direct motive. This is a relationship where one factor doesn't lead to the other "in any direct and simplistic way" but "could disproportionately set the stage within which the latter take shape in particular ways." Žižek claims that capitalism "overdetermines all alternative formations, as well as non-economic strata of social life."(2004:294). Thus values within the life sciences may not equate directly with market values, but the affordances and logics of capitalism still have significant influence over the means by which information and material in the life sciences are used and how moments of translation are negotiated.

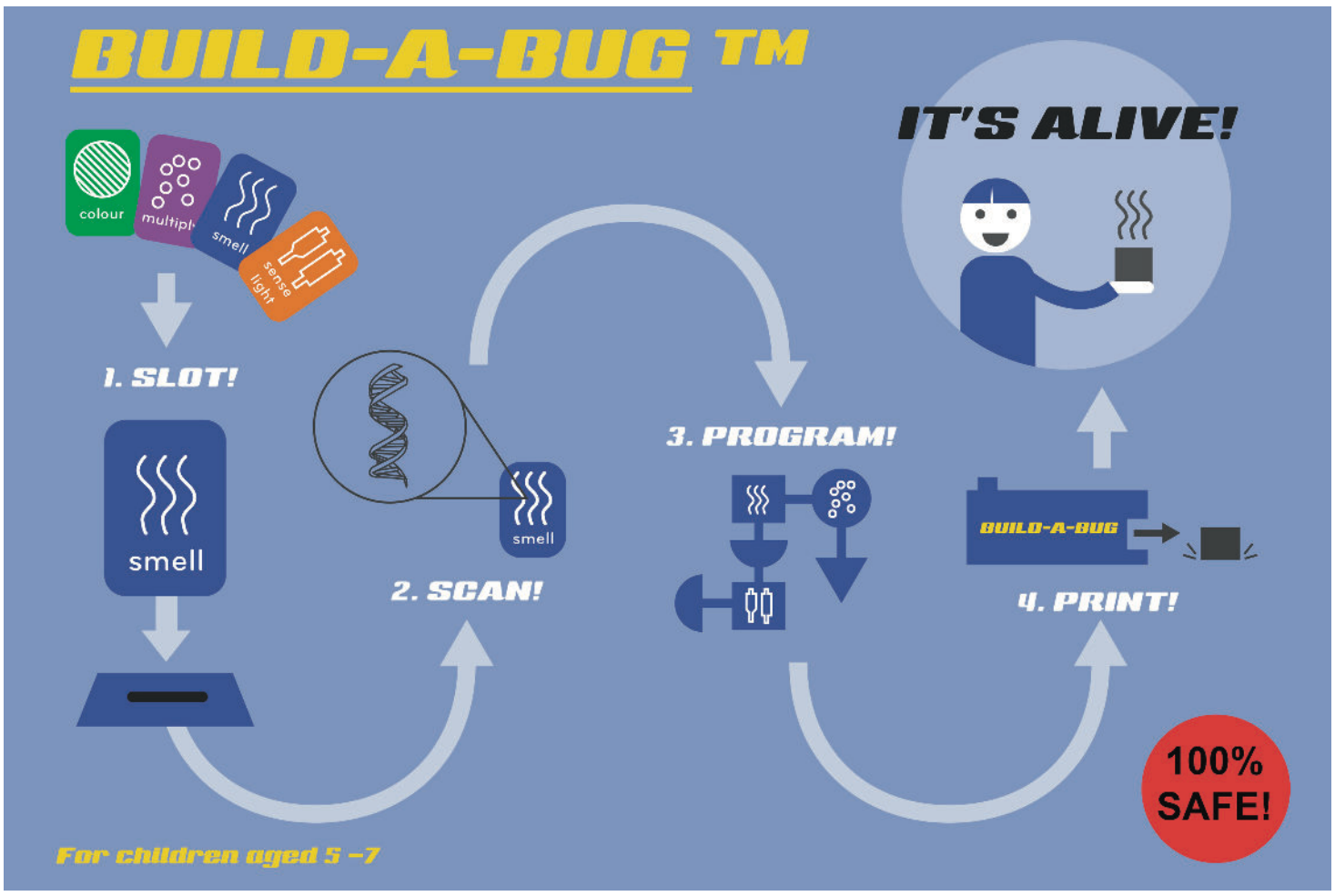
Lakoff explores how market logics shape the desire for particular forms of information in biotechnological projects. His subjects seek to identify a universally applicable 'gene for' a universally applicable bipolar disorder diagnosis in order to consolidate both biotechnological finding and the patients who form the market for the promised drugs. "To analyse the process of forging consistent illness populations... I borrow the term liquidity from the field of finance… liquidity in futures markets [is] an example of the production of standardized value - the creation of generalised knowledge about value out of idiosyncratic personal knowledge"(2012:255) Standardisation and 'liquidity' are desirable, not just in directly marketable biotechnological materials, information, or end results, but in all practices, such as the reduction of biological processes to model-able, quantifiable, molecular units. "molecularization strips tissues, proteins, molecules and drugs of their specific affinities—to a disease, to an organ, to an individual—and enables them to be regarded, in many respects, as manipulable, and transferable elements or units, which can be delocalized" (Rose 2007:36). These reduced, standardised materials flow more easily through the multiple points of translation within a capitalist system. Davies argues that a process of standardisation is necessary to permit materials, information, and regulation to move between institutions that Helmreich described above as "porous to one another"."The pursuit of translational research was articulated with a range of other regulatory and commercial practices, including the standardization of model organisms, the conformity of biological nomenclatures and the harmonization of intellectual property regimes."(Davies 2012:134) Materials which resist standardisation and conformity - which fluctuate - may struggle to move through translation points. Information with 'liquidity' flows easily through capitalist systems, is more widely applicable and exchangeable and so may be more valuable within the 'credibility cycle' and beyond.

Schyfter, Frow and Calvert note that synthetic biology is deeply concerned with the transmutation of biological material into forms with affordances amenable to capitalism, and that this is reflected in practices and nomenclature: "Genetic parts are to be standardized, functionally isolated, and capable of easy combination into complex ‘devices,’ ‘systems’, and ‘circuits’."(2013:2) Once reduced and standardised, parts

can be flexibly reassembled to fit the requirements of a marketplace. But this flexibility is not the same as the variance of biological processes- the transcription errors and misreadings which give rise to the unpredictability of life, from minor intercellular processes such as protein production through to DNA mutation and evolution. Natural biological 'stochasticity' a computer scientist informant explained to me, was so hugely difficult to model that it formed the bulk of his work and so computationally expensive that simulations could take hours to run. Instead genetic parts should "be characterized in measurable terms and should display calculable, predictable performance."(2013:2) Finlay's ethnographic account of a synthetic biology lab explores this rhetoric further. Scientists she studied wanted to control complexity, to reduce living processes to comprehensible units and rebuild them, rather than engaging organically with their variability: "Synthetic biologists really do get the point that if you take a rigorous approach for the building of this complex system you can indeed increase the complexity in a much more efficient way than it would be by just trial and error. (Grant, senior researcher, engineering)" (2013:29) Breaking down, redesigning, building and iterating on the design in a 'design cycle' process was considered to be the "most efficient and rational way to design and produce an effective synthetic biology 'product'"(Finlay 2013:30). Here the goal of productivity and 'products' for a conceptual market reflects back on the priorities and valuation of interim processes. Finlay notes that informants who did not believe the rational engineering approach could be successful were nervous about voicing concerns. One researcher that Finlay interviewed "questioned whether the parts, devices and systems approach was feasible, and whether abstraction and decoupling were achievable. Yet she concluded that she was 'scared of saying that publicly'"(2013:32). If information is valued according to its capitalist affordances- productivity, efficiency, standardisation, etc then information which is not so well suited may not be considered acceptable or credible.

The desire to produce information of particular forms shapes sites of research. In the case of biotechnology, these sites are often living things which respond to such pressures. Fisher quotes one of his informants on this problem regarding animal models for human medical treatments. "the worst problem is that all the [laboratory] mice are identical twins and people are not. If you tested in field mice you would be fine, except it would take forever" (Fisher 2012:406) The desire to efficiently produce results which are standardised and replicable leads to the use of mice which are identical- despite the purpose of the research supposedly being to produce treatments for humans, which are not. The fit to capitalist affordances does not represent a fitness for purpose. Davies' humanised mice are not only identically twinned but identically housed in sterile cages so "the species, but also the spaces, were not representative"(2012:133) of the intended target- human immune systems.

Cooper suggests that conception of organic and capital growth are deeply intertwined: "As the realms of biological (re)production and capital accumulation move closer together, it is becoming difficult to think about the life sciences without invoking the traditional concepts of political economy- production, value, growth, crisis, resistance, and revolution" (2008:3) It is 'difficult to think' of the life sciences separately from capitalism and difficult to produce information about life that is not compatible with the affordances of the capitalist system. The 'fluctuations' which are part of living organisms, are difficult to move through a system and so are less likely to be produced, and to survive negotiations through translation points in a system which values information produced to schedule and which is more easily modelled and delocalised. But as with the humanised mice, these results may not survive translation into real world settings. Latour claims that "for a scientist" who wants to retain strength outside the lab (or retain the value of information she has produced) "the solution is never going out" and that "if this means transforming society into a vast laboratory, then do it." (1983:166) This extension of the lab produces incredibly powerful results- Latour detailed Pasteur's development of vaccines as the key example. However Helmreich writes that "Family, personhood, race, crime are all refigured as the stuff of biology is made increasingly miniature and malleable." (2008:466) If the fluctuations and variability of organisms are invalidated and suppressed within the lab by the pressure to produce information compatible with capitalist values, the implication is that this refiguring of human life may also be subject to the same process.



Bibliography

Cooper, M. (2008). Life as surplus: Biotechnology and capitalism in the neoliberal era. Seattle: University of Washington Press.

Davies, G. (September 01, 2012). What is a Humanized Mouse? Remaking the Species and Spaces of Translational Medicine. Body and Society, 18, 126-155.

Finlay, S. C. (April 01, 2013). Engineering biology? Exploring rhetoric, practice, constraints and collaborations within a synthetic biology research centre. Engineering Studies, 5, 1, 26-41.

Ginsberg, A. D., Calvert, J., Schyfter, P., Elfick, A., & Endy, A. D. (2014). Synthetic Aesthetics: Investigating synthetic biology's designs on nature.

Jasanoff, S. (2004). States of knowledge: The co-production of science and social order. London: Routledge.

Lakoff, A. Diagnostic liquidity: Mental illness and the global trade in DNA. Theory and Society 34 (2005). 63-92

Latour, B (1983). Give Me a Laboratory and I will Raise the World. In Knorr-Cetina, K., & Mulkay, M. J. (ed.) Science observed: Perspectives on the social study of science(pp 141-170). London: Sage Publications.

Latour, B., & Woolgar, S. (1986). Laboratory life: The construction of scientific facts. Princeton, N.J: Princeton University Press.

Silver, Pamela A. "Making Biology Easier to Engineer." BioSocieties 4 (2009): 283–9

Sunder, R. K. (2006). Biocapital: The constitution of postgenomic life. Durham, NC [u.a.: Duke Univ. Press.

Sunder, R. K. (2012). Lively capital: Biotechnologies, ethics, and governance in global markets. Durham: Duke University Press.

Find & Replace

One new message. Urgent.

The red urgent prompt flared urgently in the corner of Harry's company smart glasses. The company system gradually filled the company glasses' visual field with the same urgent redness. Urgent. Red. Urgent. Red. LEDs along the glasses' arms flared. Again and again, each time illuminating a little more of the bare bedroom in angry light, as if a line of lorries were reversing past the window at deadly speeds.

On the 3rd desk to the left of the lift shaft in lab 9, floor 7, Building B a laptop, snug in its charging slot, alone amongst the thirty identical slots at identical desks on this row of all the identical rows, flared the same urgent red prompt, lighting up its little patch of the cavernous space. The security cameras noticed, and checked procedure, and made a note.

Gary wasn't wearing his company smart glasses or working on his company laptop that night, despite his manager's insistence that he really should spend more time doing both.

Adnan sat perfectly still in a dimply lit white cubicle, hand outstretched on an unmarked desk. He tapped fingers lightly, flicked and swiped at invisible gnats, and frowned.
"9 intensification procedures in testing, we can ramp up eval on a few of those"
A message overlaid colleagues' faces. A tap, a scan of a short statement, a swipe to evidence, the confirmation of an algorithm's decision.
"What? no. Just a minor staffing prompt. The day we can legally flip HR to automation my productivity will jump 12 points, I swear. Was there an update on feedstock?"

At 03:27 twelve laboratories received files for the printing and programming of a new robot. It was a small, simple thing, an arm with very few degrees of freedom hanging from a joint which would hook instantly to the rails suspended from the wet lab ceiling. A number of other robots had their programs updated. Labs received additional supplies. Budgets were updated to include the cost and the expected projected revenue. Sales reps received instructions about the quality and quantity of product they would be required to pre-sell.

By 11:16 all of the new robot arms were fully operational. A replacement 2nd joint was being printed for lab 6, after a temperature disturbance introduced a slight distortion to its socket's curvature, changing the parabolic path by which it would transport culture trays between machines by a couple of degrees.

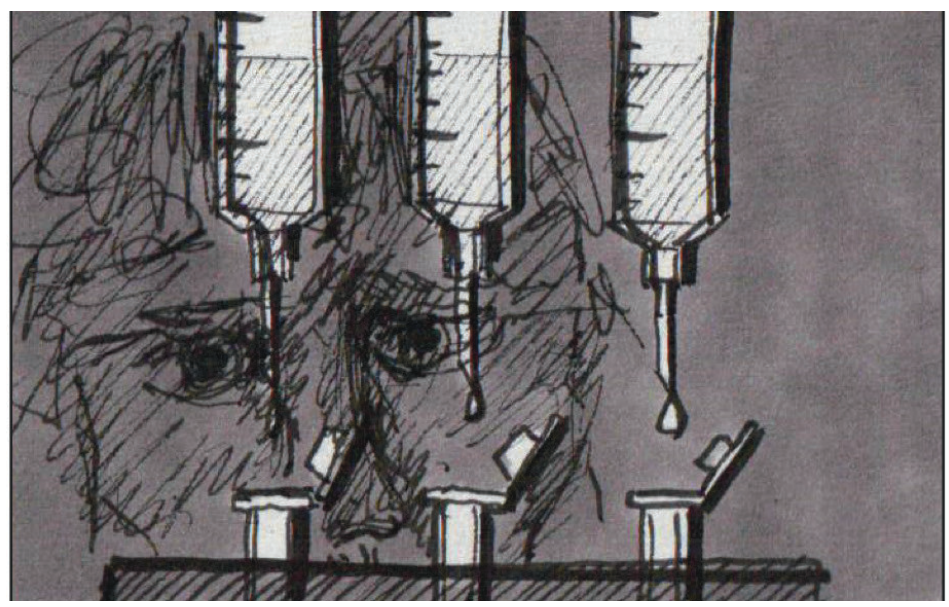
Gary's smart glasses received a compulsory automatic firmware upgrade which allowed them to display the urgent red message scrolling slowly across their lens-screens, large enough to read from across the room. He arrived home and went into his bedroom in time to see a few words scroll past.

He turned away from the message as he rummaged through drawers. He knew what it said. He checked Helena's status again. Offline. Of course. Still. If only he could run his own override on her smart glasses. But hers were not propriety, company-issued and controlled. He imagined them lying next to her on the sofa, as she watched or played or read something distracting, signed out of every message system they'd ever used. It was a tantalising possibility. Maybe? Was there some way?… but no. How long a scrolling message would it take to explain, to apologise. It was all so messy.

The 12 new robots introduced precisely the same amount of the same acid in precisely the same order to the row of culture trays that Harry had done just yesterday. They slammed the bottle down in the same corner of the tray with the same force. It had taken months of analysis to find the correlation between this source of slight agitations and the prompt beginning of the metabolisation process.
The culture trays were wheeled to their second station, the lamps were lit and the robots drooped. Gary's bored presence, his rapid, witty chats with Grace, his slow, non-comital replies to Helena's questions about dinner, bills, the imminent ID merge and new apartment, had not been found to correlate to a significant change in production. The cultures multiplied and metabolised under their lamps. The lamps; settings all adjusted themselves continually according to carefully calculated parameters based on Gary's expert, distracted monitoring.

Gary found the pieces of the photo in the bathroom bin. He had not been thorough in its destruction; his manager's frown, his colleagues' suspiciously-similar 'casual' outfits, could all be made out. Grace and her husband were missing from the chest up, but he knew her: he knew that dress. He found his own piece- miraculously he floated entirely unblemished above missing feet, but alongside him one of the rips went right through Helena's face. He held on to it. He knew he could print another copy. He knew it wouldn't be the same.

At the same moment the robots all reached in precisely the same way for the culture trays, brought them out from under the lamps, paused, and put them back into the same position. The robots were blind, but Harry's usual curious peer at the tray was correlated with increased similarity in standardisation of product metabolisation. Perhaps the slight stress of movement? The moment away and into the light triggering some unknown metabolic cycle? The change in heat? The robots all leaked a careful amount of heat, humidity, salts and carbon dioxide from a carefully engineered network of piping. The robots blindly gazed over their growing charges for the correct number of microseconds.



Gary didn't reprint the photo, or look at the ragged scraps, but he hadn't stopped holding it. He couldn't have told you why, but he wouldn't stop. yet. He spilled a little whisky pouring it out awkwardly with his left hand.

The lamps switched off, and the robots reached for their culture trays, carried them through identical labs, steering around identical equipment, at identical paces. At an unremarkable spot near the final, identical testing spot, all the robots twisted a little to face a metal panel to which printed schedules were fixed with magnets, paused for a long moment, sagged slightly and continued on their way. Like the others, the robot in lab 9 was blind and couldn't see the spare magnet where a company photo might have been hung. It didn't matter what was on the wall now. It didn't matter why the cultures performed better when they waited a little longer in this spot. It had taken the algorithm a long time to notice that correlation, to find what it was that made the replication fail in test models. Only yesterday, the cultures had arrived a little later at the third machine a little early, when the accelerometers had registered a faster pace, a lack of pause, perhaps some slight jerk as something was quickly torn off the wall. Production had stalled. the comparison was made, the mimicry was complete, and a single broken-hearted researcher could be cleanly replicated twelve times in identical clean, controlled labs.

The Dances

Yesterday I witnessed the strangest and most spectacular arts event of my life through the gaps in a wall of croissant-stuffed suits. It was luck alone that had put me up there, and gave me this chance to write this. What this is- a review, a reaction, I'm not sure- certainly not a promotion. I do not know who produced this performance or whether they ever will again. If they read this, I hope it serves as thanks.

As you move up the bureaucratic rungs in the arts there is a lot less messy wonderful discovery within the rehearsal rooms, a lot more strategising development, signing grant applications, decisions made on the basis of others' reports, attending shows to be seen, not to see. Yesterday, watching those strange abstract shapes and symbols dance together, bursting in and out of existence, shifting form, flocking, forming patterns I still see in my dreams I was reminded why I got into this strange little, industry in the first place.

That morning was at one of the regular city meet and greets which regularly drag me up the office blocks of Canary Wharf or Bank another city's finance centre to brunch with bankers. What's on, what's worth funding and seeing and having your name attached to over and over again. The view from the 40th floor of one Canada Place is of course always spectacular. The river curves around and under you, and the grey and green speckled city extends forever in every direction. But these financiers and lawyers, CEOs, CTOs, consultants and analysts are a lifeline to the artists who rely on me so I tend not to look out for long.

So I wasn't the first to notice the lights. Bored young executives who were mostly there for the (admittedly exquisite) bacon baguettes started the call to the window. Strange projections of shapes were flicking into existence on the roofs of the only-slightly-less-massive office blocks which neighboured ours. They were simple abstract things- some hexagons, triangles and rectangles. Their insides and borders were stuffed with symbols, which leaked or burst out, attached or were absorbed by others. I glimpsed many of these details through the zoomed-in image on the screen of a camera one of the bankers whipped out. I suspect there was a deeper logic underlying a lot of what I saw that was invisible from so far away.

As they divided and moved some shifted between forms, some grew and other shrunk. Through the zooming camera I came to understand that each shape was executing very simple behaviours- movements and encounters with other shapes or symbols had straightforward effects. But there were tens, then hundreds,then thousands, and it was the larger patterns growing across all visible surfaces which caught me, like the webs they mimicked.

Those simple individual logics and local interactions drove complex structures and movements. The roofs and walls were soon covered with overlapping, always moving mandalas. Small, chance interactions blossomed into cascades of signals and colours. They swarmed like insects, shoaled like fish or flocks of starlings. Some mandalas blossomed and bullied their neighbours into shrinking others faded or collapsed. Within these patterns you could spot small stories of hunts and chases. Groups sent out signals that froze or baffled others, or came together in packs to form ripple patterns that overcame their prey. Later, discussing with the other brunch-eaters what we had seen I realised that without exception, everyone referred to these simple shapes as 'alive'.

The spaces of Canary Wharf are like the finance districts I have seen and suckled for funding all over the world: glass, height and suits. It is the home of many of the extraordinary algorithms which lead our markets. At these bizarre funding-seeking brunches I've heard a hundred bankers tell me that their trades are a kind of dance. That they choreograph numbers, direct and predict their movements. They possess power that they never hesitate to remind me I will never understand. The simulation we saw, only lasted a few minutes, but it seized a few billion pounds worth of those financiers' attention, knocking their elegant predictions aside with a bright, mad laugh. We still have no idea where the projections came from. They were gone before we had a chance to begin the hunt. Suddenly switched off at the moment a particularly elegant and expansive fractal pattern seemed set to implode. Perhaps they were waiting for the simulation to reach that point, or perhaps they were disturbed at their work. Whatever the reason for their appearance and disappearance, the mirrored glass of those tall towers will never look the same.

Science Practice

Lydia Nicholas

All text and some images

Lydia Nicholas is a technology and futures-focused anthropologist and writer. She is a founding member of the Future Anthropologies Network and works with Science Practice and other research organisations. Whilst completing her MSc in Digital Anthropology at UCL she presented work at national and international conferences, including the ASA 2014 and EASA 2014. Her interests center on information form and flow. Her recent work explores conceptions of data and the body in quantified self practices, hacker cultures transversing digital and physical forms, digital privacy practices, and various biomedical projects

@lydnicholas
lydia@science-practice.com

Marek Kultys

Images

Marek Kultys is an interdisciplinary communication designer with a background in information design, interaction design, scientific visualisations and critical design. He currently works at Science Practice. He most recently presented at SETI in Mountain View, California on 'Lingua Extraterrestris' exploring how the theories and endeavours in communication with extraterrestrial intelligence (CETI) can inform our general understanding of the process of communication. His interests and practice span a number of disciplines and a range of media, but always pivot around the central problem of visual communication.

@marekkultys
mk@science-practice.com

James Godwin

Build-a-bug image

James Godwin is a multi-disciplinary designer with a background in graphic communication, interaction design (including UI and UX) and animation. He graduated in 2008 with a First Class degree in Graphic Design from Central Saint Martins College of Art and Design. James worked as a freelance designer on a wide range of projects including bespoke book, website, identity, exhibition, and information design. He currently works as a designer at Science Practice on projects for bio-medical science.

@james_godwin_
jg@science-practice.com

James King

James King is the Director of Science Practice, a research and design company that bridges the gap between scientific and cultural systems. Working with businesses, institutions and research labs, Science Practice undertakes a wide range of projects that aim to augment scientific expertise, advance innovation and support new discoveries. James is a speculative designer who has been working with researchers in biomedical science and healthcare since 2007. His work has been exhibited widely, most notably in MoMA's Design and The Elastic Mind exhibition in 2008 and at the Wellcome Trust in 2010. It has also been reproduced in many publications such as Wired, SEED and The Guardian.

@jamesking
jk@science-practice.com

Acknowledgements

Many thanks to the whole Roadblock team, particularly to those who were interviewed. Thank you for your time, patience, and honesty. It has been fascinating and humbling to learn about your work.

Particular thanks to Dr Sara Kalvala, whose document formed the core of The Dances.

Thanks also to Dr Farnoosh Ali, Dr Helen Morant, Dr Tzveta Pokrovska and Dr Bilal Rahim for their input into the Guardian surfaces interviews. Whilst these interviews extensively quote from their responses and couldn't have happened without their help they are fictional and any factual inaccuracies are my own.