Takeaway Science
Life on Mars, Controlling Disease and 3D Printers

Mike Bullivant
Welcome to takeaway science, another in the series of short podcasts produced by BLAST! at the Open University. This particular podcast comprises 3 short audio sequences. Later in the podcast Susan Conway chats with a group of Open University scientists about life on Mars and our chances of discovering it. We will also chat with Vic Oliver of Bath University about the new technology of 3D printers. But first BLAST!'s David Smith went to this year's Royal Society Exhibition where he caught up with 2 epidemiologists from Cambridge University, Professor Chris Gilligan from the Institute for Animal Health and Dr Ralph de Samoen, a post doctoral research associate. Here's David Smith.

David Smith
Um, could you explain more about your research?

Professor Chris Gilligan
We use mathematical models to try and understand how diseases spread, so that we can use that knowledge, the knowledge we gain by understanding how diseases spread, to actually control them better. So, how do we design more efficient control strategies, so ones that work, um, 'cause there's obviously constrained resources so you need to know how much, for example, how much effort do you put into surveillance, looking for the disease in the first place and how much do you actually then allocate to, um, controlling, fighting the disease. So do you look for it, spend lots looking for it but then not having very much to control it once you know where it is or do you spend lots, spend not very much finding out where it is but then, but have lots of reserves to control for it but then you don't necessarily know where it is at the time, so, kind of looking at that type of question. I'm at the Institute for Animal Health and look at primarily animal diseases and, I mean, the focus for our, of my work is looking at things like foot and mouth disease and blue tongue and, and scrapie. So mostly diseases, which are exotic to the UK, so not actually here at the moment but have can have, devastating consequences when they do arise. For example, foot and mouth disease when it came in 2001 obviously had a shattering impact both on the animal population but also on the, the rural economy and blue tongue which arrived for the first time in 2007, in the UK, which is, has potential to devastate the national, national sheep flock and imposes quite severe trade restrictions, um, so, it's important we can actually control, control this disease as soon as we can.

David Smith
This seems to be quite a specialised area of research. How did you get involved?

Dr Ralph de Samoen
Um, actually it was, er, through personal connections. I knew someone that knew someone, er, I was working in biological physics, so using stochastic processes, how does randomness affect biological systems and er epidemics are inherently random. They usually start with a small introduction, er one infected thing that spreads, er, to numerous and those beginnings of epidemics are inherently random. It's that one individual dies or, er, recovers before he passes on, then the epidemic won't even take off. So when you have small numbers it's really important to understand how random effects happen. I'm trying to bring my speciality to epidemiology. One of our collaborators, er, works on the population genetics of , er, was it take-all in wheat, right. So, er, take-all disease in wheat is a disease that kills whole fields of wheat hence the name, er and they found that there are 2 different strains of take-all that kind of co-exist and they think they came from one strain, so there might be a speciation event that happened, so it was one disease and then there are 2 and so we're trying to study, you know, how that's possible, what, you know, what could be in the ecology of the fields and harvesting

cycles that would make it split into 2 different diseases. But they're not here right now. [Laughter].

David Smith
And can you, if you look 5 years into the future, how do you see your field developing?

Professor Chris Gilligan
I mean, I mean part of it would be being able to take data in real time and then try and predict forward what, so, once an outbreak has occurred, um, how do you sort, sort of take the data of the situation as it is now and use that to try and predict forward, um, so could try and identify which farms you would need to target, you control that, whether you, I mean, for example, if you vaccinated, well you could vaccinate an area that isn't infected yet, but, use that, vaccinated barrier to try and stop, um infection. And also, one of the, one of the big, big things that have been coming for the future is the impact of climate change on disease and we know, um, for example, blue tongue, that's been spreading further north since the mid 1990s largely under the influence of climate change which has expanded the range of the vector, the biting midge that transmits the infection. Um, so we know that it can happen there, and likely in the future with further climate change it's going to allow different diseases to come into the firstly, well, probably firstly into Europe but then ultimately spreading further north so that's going to, sort of, potentially what's, what's currently exotic diseases will potentially become endemic ones, um, which obviously you've got a complete, a population which has never experienced the disease so it's going to be potentially, potentially devastating I guess.

Mike Bullivant
David Smith there talking with Professor Chris Gilligan and Dr Ralph de Samoen from Cambridge University. Well if that's whetted your appetite for epidemiology you might want to take a look at the Open University's short science course, "Chance, Risk and Health" which aims to introduce you, from scratch, to some of the main ideas of modern statistics in the context of important health issues. The course will show you, for instance, how statistics can shed considerable light on such topics as the controversy surrounding the MMR vaccine and the link between smoking and cancer. To learn more about this course or any other OU course for that matter, log on to www3, that's the numeral 3, ww3.open.ac.uk/study and follow the links.

Mike Bullivant
The second sequence in this takeaway science podcast features Open University research student Susan Conway chatting about life on Mars - and I don't mean the BBC TV series! – with 3 of her fellow OU researchers, Charles Cockell who is Professor of Geo-microbiology in the Planetary and Space Sciences Research Institute, Matthew Balme from the Department of Earth and Environmental Sciences and in the Department of Physics and Astronomy, Stephen Lewis. Over to Susan Conway.

Susan Conway
Let's imagine you've just landed, what might be around?

Matthew Balme
Well, hopefully, not too many rocks because if you land a spacecraft on Mars you don't want to land somewhere dangerous but the best way to describe it would be something that looks a bit like the Arizona desert but without any plants or perhaps the high Antarctic desert but fewer people will have been there so sand, rocks.

Susan Conway
Now Stephen, er, would you be able to give us an idea of what kind of weather conditions we might have, what the, what you might see if you looked into the sky on this imaginary trip to Mars?

Stephen Lewis
The Martian sky would probably appear quite murky which, um, reached the great altitudes. The dust is very fine, it's not like sand, it's more like smoke, um, typically on a fairly clear day,

if you were near the equator, it would, the Martian climate would be very like a desert on Earth. Um, it would be very hot during the day, um, well it might even reach temperatures well above freezing point near the surface. At night it would be incredibly cold. There'd be a huge difference, maybe 100 degrees difference. The atmospheric pressure is very much lower, it's rather like if you were about 10 miles up in the Earth's atmosphere, um, so about 6 milibars, um, about a 100th of the Earth's atmosphere.

Susan Conway
So the air would be very thin?

Stephen Lewis
The air would be very thin and, um, the wind, although the winds can be quite strong, you wouldn't actually feel the winds pushing you very much because the air, the density of the air is so low.

Susan Conway
So from what Stephen and, and Matt have been saying, Charles, it doesn't sound like a very friendly environment and we know there's no oxygen on Mars so how would life be able to survive, I mean, as a micro-biologist, how, how, what sort of niches would life need to be in to survive on Mars?

Charles Cockell
It, it's right at the surface of Mars, is a very stark and apparently dead environment, um, as Matt and Steve explained. You land on the surface of Mars but in fact, um, many of the polar deserts on the Earth also look very stark and dead but they harbour a huge amount of life. And a lot of it is underground?. Er, it's underground where there may be some liquid water, perhaps some nutrients and some geo-chemical activity to turn things over to create a constant supply of nutrients for life. And that's where you'd really want to look, er, on Mars, it's probably to drill into the sub-surface.

Susan Conway
And that would also cause a problem, to have life on the surface, wouldn't it, the thin atmosphere?

Charles Cockell
The problem is that the pressure on the surface of Mars in most places is at the triple point of water or around that. What that means is that water, instead of going from ice to liquid to gas tends to go directly from, er, ice into vapour and disappear into the atmosphere and life needs liquid water and that's the problem in most places on the surface of Mars, er, and in the deep sub-surface there may be regions where you could have stable liquid water.

Susan Conway
Okay. So what about the, er, radiation coming in from the Sun. If we don't have very much of an atmosphere would the, the radiation coming in from the Sun be a problem for microbes?

Charles Cockell
Well people always talk about radiation killing off everything on Mars and being a real problem. It's a problem if you are actually on the surface exposed to the full, er, solar radiation but it only takes a few microns, even just a millimetre of, of Martian soil to protect you from ultraviolet radiation and the levels of cosmic radiation on the surface of Mars, we know, er, can be tolerated by some microbes on the Earth. So long as you are under a few, er, yeah, a few millimetres say of Martian soil, you re protected from most of the problem of radiation.

Susan Conway
Okay. Thank you for that.

Mike Bullivant
Susan Conway there, talking with Open University researchers, Charles Cockell, Matthew Balme and Stephen Lewis. Well, if you've ever wondered about where the solar system came from and how it evolved, how and why life arose on Earth and whether there's

intelligent life elsewhere in the solar system or beyond then the OU's second level course, "Planetary Science and the Search for Life" may be the course for you because these are just some of the questions that this course addresses. The course also looks at the exploration of the solar system by spacecraft, planetary processes such as volcanism and impacts, the structure of planets and their atmospheres and asteroids, comets and meteorites. Students taking the course, "Planetary Science and the Search for Life" make extensive use of web-based resources and electronic conferencing and as it's a second level course some previous science knowledge is assumed. For more details of this course and other Open University courses log on to ww3, that's the numeral 3, again, ww3.open.ac.uk/study.

Mike Bullivant
The third and final sequence in this takeaway science podcast features a fascinating interview about 3D printers – yes, that's 3D printers with Vic Oliver from Bath University. BLAST!'s David Smith caught up with Vic at a very noisy Cheltenham Science Festival.

Vic Oliver
Good day.

David Smith
Um, we were looking at your …

Vic Oliver
… RepRap

David Smith
Um, would you explain a bit more to our audience?

Vic Oliver
Yes, er, if they are familiar with 3D printers, um, it's a, it's basically an open source 3D printer. So it's a machine that makes things, um, in 3 dimensions from a variety of plastics. We prefer to go with environmentally friendly ones, obviously. It's, um, it does things in layers. If, if, you, if you picture a glue gun on the end of a robot arm you've got the general idea, er, it lays down, er, an object in layers in molten plastic then it drops the platform down and it then does another, er, slice of the object as a layer of plastic, um, and in that way it builds the, er, object up from the bottom up.

David Smith
What sort of uses can you see the RepRap being. Um, you were taking about it's self-replicating.

Vic Oliver
Yes it is. Um, that, that aspect, um, strangely, strangely isn't the one that seems to light up the public imagination here, they are keener on seeing it producing everyday objects but, er, for the scient, those of a scientific bent, um, it does, er, reproduce it's own parts and then you can, er, put them all together and build another machine.

David Smith
So it's like, um, a large version of the nanobot in people's imagination?

Vic Oliver
Yes, or a, a Van Neumann machine. But it is a practical device rather than a theoretical one so we don't bother making things like nuts and bolts, um, because you can go to B&Q and buy those, er, for, for not very many pennies. Er, but all the brackets that hold everything together and hold all the motors in the right place and stuff like that, er, they are tricky to make and tricky to buy so, um, we use the 3D fabricator to make them and, er, that's very good with complex pieces.

David Smith
And do you think people could make these at home? Is it easy to build?

Vic Oliver
Yes, if you can, if you can stick a PC together from sort of motherboard and case then you've probably got enough skills to, to build your RepRap at home. Er, we've actually set up a foundation, "The RepRap Research Foundation". It's a, a non profit to help people to, er, put the, er, to get all the parts they need to put one together.

David Smith
And can they use any sort of novelty materials, chocolate, for example?

Vic Oliver
Ah chocolate is one I'm itching to see. In theory you can, er we, we have a design for a paste extruder, um, we tried icing, er we also tried drying icing with a hairdryer which doesn't work very well, it just turns into syrup. Um, but, um we tend to use, er, er poly-lactic acid which is, er, a bio-originated plastic, um, it's bio-degradable, melts at just over 100 Celsius, er, or um, er, polycaprolactone which is sold in Maplin as polymorph, melts at about 60 Celsius and it's great fun to play with. Er, you can get it in luminous as well so you can print your own glow stars which is quite fun.

David Smith
And what do you see this technology, um, changing in the world?

Vic Oliver
Well, what, what we've done is we've created a tool which can evolve to do what people, er, want, whatever people want it to do. Well, we can't determine, you know, what people want this device to make, um, so we have made the design free and open and all the tools that you need to modify it to be free and open, um, so that people can take this, er, Reprap and put it into, er, well whatever environment they are in and, and make it work.

David Smith
To use in the middle of the desert to outer space?

Vic Oliver
In, indeed. Um, that's actually how I got into it but, um, yes, er, the more, er, the more remote the environment obviously the handier it is for you to be able to make your own bits and pieces.

David Smith
As long as you have the plastic to put into it.

Vic Oliver
Yes, well, we, we have actually used poly-lactic acid because people can, er, make it from starch. Um, so you can, you can grow your own plastic in effect.

David Smith
What would you say to get people interested?

Vic Oliver
This project is great because basically it allows you to make what you want, um, so if you go along to reprap .org, that's R E P R A P dot org and literally everything that, er, you want to build, that project is up there on that site and it covers a whole range of things, um, from so, simple mechanics like a big meccano set, um, to the electronics to material science of the different plastics, er and there's really something in there for everybody of a scientific bent, er, and it's great for schools. Um, in fact we're undergoing negotiations to, er, provide a training course for teachers, er, where the teacher would go along er, to the course, er, build themselves a reprap and understand the principles of, of making it and then go back to their school with a kit and put it together with the children.

David Smith
And is there any issues, like legal issues with copyright, with 3D printers?

Vic Oliver
Well copyright is, is one thing. Um, for example, if you were to, um, start producing models of a certain mouse light, mouse like character, well known, obviously, you might indeed attract the attention of copyright lawyers. Um, but for items that are patented in this country, at least, and in many other parts of the free world, you are allowed to make patented objects for your own use, um, provided that you, er, don't sell them or sell goods and services based on them.

David Smith
Thank you very much.

Vic Oliver
Thank you.

David Smith
Cheers.

Mike Bullivant
David Smith there talking with Bath University's Vic Oliver. Well if you enjoyed that check out the Open University course, "Engineering in the Future" which offers an introduction to engineering principles as they are applied in modern engineering practice. This course will also teach you general skills such as numeracy, critical reading and analysis, writing reports and essays, problem solving and learning at a distance. You will also look at the historical development of engineering, how it's practised today and future engineering trends. You can find out more details on www3.open.ac.uk/study. Well that's the end of this particular podcast brought to you by BLAST! at the Open University. Er, for further podcasts in this takeaway science series revisit the Open University's science faculty website at www.open.ac.uk/science and if you want to find out more about some of the science outreach work carried out by the OU visit the BLAST! web pages at blast.open.ac.uk. Anyway that's all for now so from me, Mike Bullivant, adios amigos!