Celebrating genomic breakthroughs - Insights from the Festival of Genomics

The G Word Transcript

**Vivienne Parry: Hello and welcome to the G Word.**

**Vivienne Parry: The Festival of Genomics is the UK’s biggest genomics event, and it’s become an essential part of our year. It’s free for 90 percent of its delegates, it’s in person, and with more than 5,000 people expected, it’s now so big that it’s had to move to ExCel’s cavernous Dockland Halls. It’s the place to hear top science and to spot new trends, but actually for me the joy of the festival is the people you meet. Of course, it’s great to catch up with old friends, but it’s the new collaborations sparked by random encounters at the festival which I think are the lifeblood of the genomics ecosystem, and everyone with an interest in genomics is here, patients, clinicians from the NHS, researchers, industry, policymakers, and the G Word.**

**What we thought we’d do is bring you a flavour of this great event from the floor of the ExCel halls, and give you a quick soundbite from three of the speakers that we felt best exemplify the future of genomics. With me to discuss the event and future trends in genomics, Professor Matt Brown, Genomic England’s chief scientific officer, and Louise Fish, CEO of the Genetic Alliance UK, which as its name suggests, is an alliance of over 200 organisations reflecting the needs and concerns of those affected by genetic conditions. My name’s Vivienne Parry, I’m head of public engagement at Genomics England, and I’m delighted to be your host for today’s pod from the Festival of Genomics. Welcome to you both. So, let’s start with you, Matt. How important is the Festival of Genomics for genomics in the UK?**

Matt Brown: Well, the Festival of Genomics has become a really key meeting for the genomics community in the UK, and I think increasingly in Europe as well. It’s a really large, high quality event that brings together commercial and academic and biotech companies in the one forum, and I think it’s a really exciting programme.

**Vivienne Parry: And of course, Louise, it’s open to patients as well, which makes it an unusual event.**

Louise Fish: Absolutely, and it’s brilliant to have patients and families here. So, people living with genetic conditions clearly need to be part of the debate when we’re talking about developing new services, and developing new treatments and diagnostics, so it’s absolutely fantastic to be able to come together in one room with people from the NHS and the broader sector.

**Vivienne Parry: And it’s grown enormously, and I guess that reflects, as much as anything else, just how exciting genomics is. Matt, I’m going to pin you to the ground [laughter] and say, why is it so exciting in genomics at the moment?**

Matt Brown: Look, the field’s really hitting its tracks. We’re seeing advances in technology, analytics, application in the clinical space, and of course booming commercial activity associated with that. But from a situation ten years ago, where we had research capability for using genomics to assist in diagnosis and cancer profiling, now we’re in a situation where we have multiple different approaches to assist with both of those things, transcriptomics, proteomics, spatial, single cell methods, optical mapping, a whole monopoly of different technologies that have developed out of the research world but are pretty close to being ready for clinical application. Of course, in analytics, the rise of AI and the potential that has for improving interpretation of genomes and improving personalised medicine prediction in cancers and in multivariant data, those are absolutely massive things. But aligned to that, there’s also, you know, the growing worldwide application of genomics in clinical spaces, of course led through the UK and the NHS Genomic Medical Service, which has really shown the way for the world about how this might make a difference.

**Vivienne Parry: And Louise, that’s the really exciting thing is we’re now seeing not just talk about therapies, we are seeing the therapies for rare disease actually going into clinical trials and into services even.**

Louise Fish: Yeah, absolutely, and that’s why people living with genetic conditions and their families want to see the change. The scientific breakthroughs that are being made are absolutely incredible and they’re really exciting, but from the point of someone living with a genetic condition, what they want to see is those scientific breakthroughs making a real difference in the clinics. And that’s sometimes about treatments, you know. For some conditions, it’s about treatments, but it’s also about being able to get a diagnosis faster, to be able to understand what condition is impacting on you, how it might affect you over your lifetime and your wider family, and to be able to work with NHS services to understand and plan for the care and treatment that you’ll need throughout your lifetime. So, treatment’s one part of it, but actually that ability to better understand what the future will hold for you, and to plan ahead for the care and support that you will need to live your life to the full is what really excites people living with genetic conditions and their families.

**Vivienne Parry: Now, let’s hear the first of our three clips. The programme is absolutely vast, but these were three presentations that we just thought were terrific. Let’s hear the first one.**

Nagy Habib: My name is Professor Nagy Habib. I’m a consultant surgeon at Hammersmith Hospital, Imperial College, London. We are going through a very exciting time, where we know what is the problem with the diseases, and so far we couldn’t do anything about it, but suddenly the door is opening and it all came with the RNA vaccine, because we had to go very fast to get a vaccine for covid, to protect the population, and that pushed the science to go very fast, and now we can apply it to other areas apart from covid, like cancer and rare genetic diseases. And these therapeutics are what you and I and everybody else have received during vaccination. There has been six billion injections around the world, so you can imagine that everybody had an RNA injection. And RNA is that molecule between our genome, the DNA, and the protein. For anything to happen in our body, it requires the protein, but there must be an RNA in between. In the past, it was all about DNA, but now it is RNA. Why can’t we get a vaccine against cancer?

And so now the field is growing very fast for a vaccine for cancer. Now, the way we think about it is that we can have an injection so that we don’t develop cancer of the prostate or cancer of the breast and so on, but in actual fact today what we can say is that if we take out a tumour with surgery, and we can take the RNA from the tumour and inject it in the patient, the early clinical trials tell us that this might work, and to stop the tumour coming back. It is very important to make sure that, once the tumour is out, it doesn’t come back. And I think there is hope that we can have RNA vaccines in cancer. Now, to treat cancer without surgery, still we have some way to go, but again, now we know that the problem with cancer is that some of our immune cells that are there to defend us from cancer, they change their mind and suddenly they collaborate with the enemy. So instead of helping us, they are destroying our immune system, and we are developing drugs that can stop that from happening to our immune systems.

Now, when you really think about what are the diseases that kill people, cancer is definitely very high up. The second one, not in a particular order, but cardiovascular system, we get heart attacks and we die from heart failure, or we get stroke and we die from stroke, and that’s because we eat too much. The food is very tasty [laughter]. So, now we have injections, and the injection can make us lose weight, and we lose weight very fast. The problem is again it’s very expensive. Who can afford £600 a week? And when you stop the injection, you put on weight again. So, now we are working again with RNA, and we have found a way where you inject only once every six months.

And then the final thing, which is really the dream of everybody, is to stop Alzheimer’s disease. So, Alzheimer’s disease, as we get old, there are toxic materials that are accumulating in our brain cells, and only this year we’ve got two drugs coming along that can help stopping Alzheimer’s disease at an early stage. Now, what we need to do is to bring that it works on all types, even the advance type of Alzheimer’s disease, and now there are [inaudible 0:09:26] where we can take it from the nose. So, you inhale it from the nose and it goes straight to the brain, because there is sort of a motorway that connects the roof of the nose with the base of the brain, which is very simple. It doesn’t even need an injection in the arm vein. So, it’s all very, very exciting.

**Vivienne Parry: That is so fascinating. It’s real future casting. Matt, I mean, I say it’s future casting, but tell me a bit about the Rare Therapies Launchpad, because, you know, that picks up some of what Nagy has outlined.**

Matt Brown: Yeah, so DNA and RNA therapeutics are absolutely booming, and that’s one of the big excitements is that we’re not only being able to diagnose people, but we’re coming up with new ways of actually providing treatments for patients with rare diseases and cancers through nucleic acid therapeutics. For rare diseases, the type of clinical trials that are involved are really quite different, and you can’t just basically translate what was used for common diseases into the rare disease space. It just doesn’t work, and that’s really held back the field a lot. So, to try and enable rare therapies to actually make that leap from a research setting into actual clinical practice, Genomics England, in partnership with the Medical Health Regulatory Authority and others, have set up a Rare Therapies Launchpad, to provide an end to end solution for people to be able to run clinical trials for rare and ultra rare diseases, particularly focusing on nucleic acid therapies, and linking that with both the regulatory authorities and health funding authorities so that we can get these ultimately into clinical practice. I think we need these sorts of initiatives so that we don’t continue to see rare therapies falling over because they’re being assessed and made to go through the hurdles that common therapies do nowadays.

**Vivienne Parry: So Louise, we really are in the area of what people call N of 1 medicines.**

Louise Fish: Yeah, absolutely. So, these are medicines that are made specifically for one person and will help that one person, and obviously that brings a whole heap of possibilities for people living with genetic conditions, but also a load of challenges that we understand for decision makers within the MHRA and NICE and the NHS. And so I think there are some real challenges that we’re really aware of from the decisions that are already being made by those decision making authorities about treatment. Obviously, putting it at the most basic level, you don’t have the same evidence base for treatment that’s just available for one person that you do from a clinical trial, where thousands of people will have taken part in a trial to understand how it affects a whole host of people.

So, we know that the decision making bodies are going to need to take a different approach to evidence, so are going to need to be willing to look at evidence that is just from a trial involving one person. They’re going to need to be able to extrapolate the benefits of that treatment across someone’s lifetime, and that can be challenging, and we’ve seen that before in rare disease medicines and the new treatments that have come along in recent years. So, there are definitely some challenges, and we’re really glad to see those challenges being acknowledged upfront by Genomics England, the MHRA and others, and being debated and discussed, and trying to find solution now rather than waiting for those treatments to come along later, and then trying to retrofit and decide how to manage them. So, it’s great to see this debate taking place early, and we’re really keen to make sure that the voices of people living with rare conditions and their families are part of that discussion.

**Vivienne Parry: And the really cheering thing that we’re hearing from Professor Habib is that he thinks that the cost is going to be much less, because some of these things, you know, have million pound price tickets, so to have something that will be cheap is really going to be I think the gamechanger.**

Louise Fish: One of the challenges with that is understanding the lifetime costs of someone living with a genetic condition and all of the complexities that are involved, and not just the medical care that they need, but the social care and the wraparound care that they’ll need, the extra support from schools and colleges, the extra support from employers if they’re able to go in employment. So, I think we’re constantly trying to help the government and decision makers have a better understanding that those lifetime costs of living with a genetic condition are the things that should be taken into account when they’re making decisions about a new treatment that could be totally game changing for someone’s health and their future.

**Vivienne Parry: Cheaper treatments on the way, Matt?**

Matt Brown: So, I think we absolutely need to work on reducing the costs of these treatments, because at the moment the costs are so high that, were we to extrapolate that out to try and treat the thousands to tens of thousands of different rare diseases that there are out there, we couldn’t possibly afford it. I think it’s very promising that we will get cheaper treatments. This might come about through reducing the development costs, in particular reducing the clinical trial programmes, and the level of safety and efficacy evidence that you require before you can actually make these treatments available. I think that will make a massive difference, if we can simplify that.

And another thing is, by better collaboration between the different rare disease communities and genetic medical services around the world, to make sure that what might be an N equals 1 condition in the United Kingdom, when you consider it around the world, might actually be an N equals 100 people, and then basically the cost per patient drops substantially. To achieve that, we need much better coordination between the national genomic medical services.

**Vivienne Parry: At the end there, you heard talk of using RNA therapies for obesity and Alzheimer’s, and we principally talk, particularly in Genomics England, not just about cancer and rare disease. But I wanted to present to you another presentation, which I just thought was extraordinary, which comes from the Netherlands, and it’s about picking up signs of diabetes using genomics ten years in advance. Just listen to this.**

Harold Sneider: Hi, I’m Harold Sneider, I’m a genetic epidemiologist working at the University Medical Centre in Groningen in the Netherlands, and my focus is on cardiometabolic disease, and I have a great interest in hypertension, for example, obesity, but also type two diabetes. So, one of my major interests is to try and identify genes for common complex, mostly cardiometabolic diseases, so our approach is to do genome-wide association studies using genetics, but also epigenetics. And epigenetics can be screened for so-called methylation markers, and those methylation markers have an effect on expression of the genes, and we can look at this all over the genome. Then a very interesting question came up, whether these types of epigenetic signals or methylation markers could actually be used to predict disease in people that are still healthy.

So, the goal of this type of work always consists of two parts. First, it’s that we try to find out which genes are highlighted by these DNA methylation markers, because they are located at certain positions on the genome, so we know which genes are involved in those regions and we can learn more about the underlying biological mechanisms that play a role in the development of the disease. Because we found those signals up to ten years before the disease occurred, so that tells us something about changes that already happen at an early stage. It’s like an early detection mechanism. At the same time, a combination of these markers together lets you calculate what’s called a methylation score that can be used for the prediction of the disease, and the ultimate goal here is that even in healthy individuals, when you have those measurements, you can calculate such a score to improve the prediction and identify people with a higher probability to develop such a disease. I definitely think we can apply this general approach also to other – for example, cardiometabolic diseases, such as coronary artery disease or also hypertension.

**Vivienne Parry: Harold Sneider there from Groningen. And extraordinary, the idea that you might be able to pick up not just diabetes perhaps ten years in advance, but also he was talking about potential for other lifestyle diseases, like cardiovascular disease, for instance. What are your thoughts about that, Matt?**

Matt Brown: Look, I think it’s always been an aspiration of the clinical community to move treatments from treating patients with established disease to actually working in really early or preclinical spaces, where you’ve got a much better chance of preventing end organ damage, and secondly you’ve got a much better chance of actually inducing remissions or potentially actually curing diseases. And I think not just in diabetes, but also in a range of immune mediated diseases, there’s pretty good evidence now that you can, by intervening early, really make a massive difference to the natural history of diseases, and new methods are coming about to identify those patients, be it polygenic risk scores or other biomarkers, to enable us to sort of flip the approach of medicine from being reactive to pre-emptive.

**Vivienne Parry: And rare conditions, as they do so often, Louise, are leading the way in understanding the issues, which will then spill out into a much wider area of the population.**

Louise Fish: Yeah, absolutely, and rare conditions obviously is the space that we work in. So, Genetic Alliance UK, as you say, is an alliance of around 230 charities that support people largely with rare genetic conditions, and many of those charities are condition specific or look after groups of conditions, like metabolic rare diseases. So, that’s the kind of space that we come from, and obviously in our space, the excitement is around the work that we’re doing with Genomics England around the Generation Study, and trying to use that to understand whether it's possible to screen babies to understand whether they have a rare genetic condition, and if so to identify that condition and intervene early. And again, excitingly, that’s not just about treatment, it’s about whether there’s a way of helping that child and their family, if you can identify very early to help really improve their lifestyle choices. And one of the best examples we have is identifying children with brittle bone disease, where if you pick them up through screening, you’d be able to teach their parents to handle them safely, so they didn’t have breaks in their bones as babies, which is what we see now.

So from our perspective, it’s obviously different to the polygenic risk scoring, but again it’s that idea of using genomics as a way of identifying conditions very early, and intervening before signs and symptoms start, to try and improve the life chances of the person living with that condition, and help their wider family to help them, which is really exciting from our perspective.

**Vivienne Parry: But the experience and knowledge that you’ve gained as rare disease organisations actually is enormously valuable to other people. I mean, rare has always been at the forefront. I mean, in cancer, for example, it was chronic myeloid leukaemia, which was a rare cancer, that kind of unlocked cancer targeted treatments for everybody else. And it always seems to me that rare is at the forefront. Although it’s often seen to be behind, it actually is the key to unlocking so many other things, and the experiences that you have all had are so valuable for much wider populations.**

Louise Fish: Yeah, absolutely, and one of the reasons we run Genetic Alliance UK is so our member organisations can learn from one another, ‘cos there’s always one of the rare patient organisations which is surging ahead in a particular space, doing something really exciting, doing something really new, and we try and make sure that our members can learn from one another and don’t have to kind of reinvent that wheel. But I know that spills out into the wider cancer space and beyond, which is fantastic.

**Vivienne Parry: And Louise, do you think there are particular conditions which, if I can put it like this, are on a roll at the moment, where genomics is really advancing fast for them?**

Louise Fish: Oh goodness, that’s a really good question. There are lots of conditions where genomics is making a significant difference really quickly. For us, I think we go back to the Generation Study, and at the moment we only screen in this country for nine conditions, soon to be ten with the addition of a new condition, but the Generation Study’s looking at 200 conditions and whether it’s possible to screen for them. And for all of those 200 conditions, it’s a really exciting opportunity to see if we can learn more, both about the potential to understand and develop treatments early, but also just about the chance to understand the natural history of that condition so much earlier than we do at the moment. And I think that’s it, it’s that understanding of the natural history of the condition really early, and understanding how a family can be helped through all the aspects of the condition, which is giving people most excitement, I think, alongside the potential to develop treatments.

And I know we talk about treatments a lot, but at the moment only five percent of rare diseases have a condition specific treatment available, so we really try and balance, within Genetic Alliance UK, that hope for the small number of conditions that do have treatments, which is really exciting, or have treatments in development, and actually making sure that the scientific breakthroughs in genomics are something that all conditions can benefit from, whether there’s a treatment or not. The potential for early identification of people with a condition, understanding the natural history better, and wrapping a package of support and care around people that is not just about a drug itself, is really important to us and to all of our members.

**Vivienne Parry: Matt, are you seeing any particular areas where there’s a really rapid success?**

Matt Brown: Look, I think there have been some absolute standout successes in nucleic acid therapies in recent years. So, one is the treatment of familial hypercholesterolemia, with siRNAs for PCSK9, so the Inclisiran type approach, which has absolutely revolutionised management of that disease. In recent times, I’d highlight, for example, the treatment of sickle cell disease, an absolutely massive global problem, and now we’ve got a therapy which can really control sickling crisis and make a big difference to a disease which isn’t just a disease of developed countries, in fact it’s particularly a disease of Africa, of course. On a global level, that’s just going to have a huge effect.

But I think, yeah, I just would like to come back to that comment you made about things starting with rare diseases. So, in genomics, rare disease genomics has taught us a heck of a lot about what drives common diseases as well, and to my mind, gold dust for drug development companies is where you have genes that are associated with both rare and common forms of the same type of disease. And that tells you that basically you’re very likely, through your treatment, to be able to actually influence the disease, and that it will influence a large proportion of patients with the disease. So, I’m really enjoying seeing this division between rare diseases and common diseases broken down a little bit, and a lot more learning in therapies going from one to the other.

**Vivienne Parry: Let’s move to a completely different area, one that’s very important to Genomics England and less important, Louise, at the Genetic Alliance UK, which is cancer. We’re going to hear from Lennard Lee about cancer vaccine.**

Lennard Lee: I’m Dr Lennard Lee, I’m a medical oncologist, so I practice as an NHS doctor, treating cancer, and I’m an associate professor at the University of Oxford. We’ve come to a position whereby vaccines can be developed quicker than anyone thought. In the last few years, we’ve realised that the technology has moved on rapidly, MRNA technology, and you can make vaccines and update them really, really quickly. We’ve now come to a situation where vaccines can be made against cancer, and this is where genomics is really starting to supercharge this technology. If you can sequence a cancer then what we’re finding now is that the technology now exists for you to print off an MRNA vaccine for that patient, a truly personalised product. And it’s amazing because the genetic basis of the cancer, what the genomics sequencing shows then becomes a vaccine itself. The vaccine is designed based on that sequence, and that’s why genomics has really supercharged this field of vaccinations for cancer.

One of the possible things we just need to clarify and be aware of is that when people talk about cancer vaccines, they mean a number of things. Ultimately, what it involves is getting a new treatment for people with cancer, because it’s based on their genetic sequence, so it’s used to treat people with cancer. The future’s an exciting one, truly personalised medicine based on genomics. Genomics is going through so many different phases in the field of cancer. Firstly, we were starting to understand why cancer happened and what patients outcomes were. The second phase started to kick off where genomics would help patients select the right drugs at the right time for them, which is amazing. And now we’ve entered the final evolution of genomics, where it now becomes the actual drugs that we treat people with. And cancer vaccine is one of the first potential areas where genomics will start to form the basis of the treatments going ahead. In five years’ time, we’re going to know if it works or not, where an individual vaccine based on the genomic abnormality seen in that cancer is going to give better outcomes for patients than an off the shelf product.

We know that every cancer’s different, so genomics has showed us this, but all of a sudden that sequence could become that vaccine, which then primes that immune system, truly personalised therapy. And it is so exciting that we’re going to be talking about this in this festival, and it’s being driven as from the UK, which has got so much strength in terms of genomic capabilities as we’re developing vaccines.

**Vivienne Parry: So Lennard Lee there, absolutely confident of the importance of cancer vaccines. Matt, what are your thoughts on that?**

Matt Brown: I think it’s a tremendously exciting field. The early data on cancer vaccines with melanoma, for example, showed that for a cancer which previously had been resistant to virtually all of our approaches, is actually quite responsive to novel cancer vaccine approaches. We are yet to see across what diversity of cancers this is actually going to work, so there’s clearly a huge clinical trial programme that’s going to be required to drive this, and the UK is playing a really central role through the Cancer Vaccines Launchpad that Lennard’s involved with running, in creating the evidence base about whether these are going to achieve the promise that they hold.

I also think that they’ve got a lot of possibility for inherited cancer types. For example, I think the programme’s looking at cancer vaccines for Lynch syndrome, to try and prevent colorectal cancer in that group of patients. So, I think they’ve got lots and lots of opportunities, and it’s nice to see something positive actually coming out of the pandemic like this, for what was a pretty bleak episode worldwide otherwise.

**Vivienne Parry: They are a small part, I know, of your organisation, Louise, but in some ways, those people with inherited cancers in their families are seeing the benefits of genomics on both sides, both in that earlier diagnosis, picking up right from the very beginning, and of course in the promise of these new treatments.**

Louise Fish: Yeah, absolutely, and you’re right, it’s a small part of our remit. We do have some organisations in our membership who specifically support people with rare inherited cancers, and we work very closely with an organisation called Cancer 52, who also represent organisations with rare cancers. I’ll just give them a quick shoutout in case anyone listening is not aware of them and their amazing work. But you’re right, I think there are a couple of things going on that are really exciting in the cancer space. It’s that ability to better understand why some people are likely to inherit cancers, how that pattern works within families, and to support those families and help them understand like the risk that they have, and to make informed decisions about their own treatment and care in the future. And also about whether they want to have children, and if they do want to have children, kind of how they want to approach that to try and reduce the risk of passing on that heritability. So, that’s a really important part for everybody. I think there’s also potential to develop new treatments, which is absolutely amazing and really exciting, and it is really exciting to hear about the potential for cancer vaccines.

The other area where I think people living with inherited cancers are interested to find out more is what impact it might have on better understanding which treatments will work for which people. And we know, for example, that there are some cancer treatments that only work for one in four people with that particular kind of cancer, but it’s been really hard to understand why that’s the case. And I think the potential for genomics to identify which people could benefit from a particular cancer treatment would have two huge benefits. A, cancer treatments, many of them are really horrible, you know. They’re horrible things to go through, and if you had a better confidence that a particular treatment was going to work for you because of your genetic makeup, that would make you a lot more confident about deciding to try that treatment, and taking on board the side effects of the treatment and how it’s going to impact on you.

That would also obviously massively impact on the cost effectiveness of that treatment. At the moment, we might give it to four people and only one of them would benefit, but you’re paying for the cost of giving it to all four people. If you could identify in advance which people were more likely to benefit then you’d give it to fewer people, they’d be more likely to benefit, and the cost would come down. So, I think that there is real potential in this field of genetics and genomics to help in all kinds of ways that people living with these conditions are really excited to see and explore.

**Vivienne Parry: So Matt there, it’s not of course simply about identifying, you know, what the cancer is like and its genomic makeup, but actually it’s that wider field of pharmacogenomics, which is a big feature of the programme at the Festival of Genomics this year. And we’re very much involved in that, aren’t we?**

Matt Brown: Yeah, we are. So, pharmacogenomics is one of those areas where genomics is about to make a big difference in clinical practice. What we’re hoping to get to is the point where we have people who are not yet treated with a medication actually already have the genetic profiling done, so that when they go to a general practitioner or a physician and be prescribed a medication, the data will already be there to say what the appropriate dose should be, and whether they’re at risk of getting adverse reactions to those medications, so we could avoid them or use alternate medications. So, that sort of pre-emptive pharmacogenomics is just over the horizon, and if we can achieve that, we’re going to significantly improve patient care and reduce the risk of adverse drug reactions, which are a major cause of morbidity and hospital admissions not just in the UK but worldwide.

**Vivienne Parry: So Matt, perfect segue into our next question, which was, you’ve already identified one area which you think is going to be big in the next few years. You’re both absolutely in the centre of the genomics ecosystem. What do you think we’re going to be seeing at next year’s Festival of Genomics? What do you think is going to be the big thing that’s coming up on the inside rail?**

Matt Brown: So look, I’d like to say what I think’s going to be in next year and what I think’s going to be in ten years. Next year, I think the big things are going to be advances in AI and genomic analytics. That’s really ramping up fast, and I think we’re going to see it in clinical implementation a lot more next year. I think the cancer therapy vaccines are going to be really big next year, as are nucleic acid therapies. Multiomics for rare disease diagnosis and cancer personalised medicine, I think is also ramping up very fast. In ten years’ time, the two areas that we’ve not discussed so far where I think genomics is going to make a big difference are going to be in infectious diseases and in pathology services. In infectious diseases, genomics I think has a fair chance of replacing to a large extent culture based practice, or serology based diagnosis of infectious diseases, which will be done by sequencing instead. And that will be a massive change to the practice there, because you’ll be able to rapidly work out, even if people have been treated with antibiotics already, what the infections are and what the likely treatment responses are going to be.

Louise Fish: So from my perspective, next year what I hope to see is people getting just as excited about the differences that some of the technology we hear about this year are actually making when they’re being applied in clinical practice. So I think from my perspective, it’s all about that move from being excited about the science to seeing people just as excited about the difference that science is actually making when it’s benefiting people living with rare conditions and their families through clinics across the UK and the NHS. Next year, I’d like to hear that excitement when people are talking about how it’s actually affecting real lives. In ten years’ time, I hope we’ll be talking about the massive difference that some of the amazing techniques we’ve heard about here this year have made to the lives of people living with genetic and rare conditions.

So, you know, in ten years’ time, I hope that some of the treatments and the opportunities and the tests we hear about today, we can see how they’ve affected the natural history of the condition across ten years of lives, and that we can really see that people are living their lives to the full as a result of the fantastic technological breakthroughs that we’re hearing about today.

**Vivienne Parry: Fantastic. It’s been great to talk to you both, and it has been a fantastic festival.**

**Vivienne Parry: So, thank you to you again, and also thank you to Frontline Genomics, who organised the Festival of Genomics, because it really has been a wonderful, wonderful event. And if you’re interested in things genomic, you can subscribe to the G Word on your favourite podcast app, and if you’re new to our podcast, and we always welcome our new listeners, do check out our back catalogue. You’ll find it’s really extensive. There’s a wonderful set of genomic listening available to you, in which even spatial transcriptomics gets explained. I’ve been your host, Vivienne Parry. This podcast was edited by Mark Kendrick at Ventoux Digital, and produced by Naimah Callachand, and it's very good to have had you with us. Bye for now, and hope to see you at the Festival of Genomics next year.**