Early Career Researchers

The G Word transcript

**Will:** Hello and welcome to the G Word. My name is Will Mackin. I'm a clinician and researcher at the UCL Queen Square Institute of Neurology and Great Ormond Street Hospital, London. My research focuses on genomic medicine, especially in relation to mitochondrial disease. I'm also an Early Career Researcher representative on the Genomics England Clinical Interpretation Partnership Board, the GECIP board. And my role within the GECIP board focuses on enhancing ECR participation.

On today's episode, I'm joined by Nicky Whiffin, who's an Associate Professor and Sir Henry Dale Fellow at the University of Oxford, and she's also quantitative genomics representative on the GECIP board. I'm also joined by Charlotte Durkin, Head of Program for Molecular and Cellular Medicine at the Medical Research Council. And finally, by Jamie Ellingford. Jamie is Lead Genome Data Scientist for rare disease at Genomics England, and he's also a Senior Research Fellow at the University of Manchester. Today we'll be discussing how ECRs navigate and position themselves within the ever-changing field of genomic research.

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Before we start, I wonder if we could all introduce ourselves and maybe you could tell us a bit about what drew you into the field of genomics in general. So, Nicky, I wonder, could we start with you? Could you tell us a bit about how you got into genetics?

**Nicky:** Hi everyone. My name's Nicky, Associate Professor and Sir Henry Dale Fellow with the Big Data Institute at the University of Oxford. So I've led my team there now for about three years and moved in the middle of the pandemic and we kind of focus on finding new genetic diagnoses for rare disease patients. outside of kind of traditional protein coding regions of the genome. I guess my fascination with genetics started actually when I was quite young, so my cousin actually had a diagnosis of Duchenne muscular dystrophy, which got me fascinated about how he had it, but his brothers didn't.

I very much remember being sat in a genetics lecture in my undergraduate degree where the wonderful David Summers gave us an introduction to genetic inheritance, and I was immediately hooked and fascinated. And later, I guess I made the jump into genomics specifically because I think of the potential to make a tangible difference to kind of patients, uh, which I think is great.

**Will:** Fantastic. Uh, how about you Charlotte?

**Charlotte:** Hi everyone. Thank you so much for having me on, I'm really excited to be part of this podcast. I'm the Head of Program for the Molecular and Cellular Medicine Board at the Medical Research Council. At MRC, we find a range of investigator led research and large-scale investments related to genomics.

So from tools and technology development research at the molecular and cellular scale all the way through to genomics at a population level. I should caveat my input to this is, I'm not a genomics researcher, but I've always had an interest in the field. I started my undergraduate shortly after the Human Genome Project concluded and remember there being such a huge excitement at the time about how this is going to revolutionize our understanding of health and disease.

And so it's been really interesting to follow progress over the last two decades in genomics and I'm really excited to see what the progress for the next decade holds, because there's so much happening in this area.

**Will:** Totally agree. Thank you Charlotte, and Jamie?

**Jamie:** Hi everyone. So I am Jamie Ellingford. I'm in a really fortunate position that I get to wear two hats and, and have two different roles.

So in one part of my life, I act as Lead Genome Data Scientist at Genomics England, where we as a team of genome data scientists and bioinformaticians help to develop some of the, the software and the pipelines that are applied in genomic healthcare. And the other part of my life is as a Senior Research Fellow at the University of Manchester, where I'm really interested in the functional impact that genetic variation can have, both in terms of how a cell normally functions and how some of those variants can actually lead and cause particular types of genetic disorders.

So my interest in genetics has actually been quite a windy path really. I was absolute fascinated in the concept of evolution from quite an early age and about how slow change could give rise to these magnificent things. If you look across different timescales and kind of roundabout, I don't know, high school or A-level sort of stage of life, realising that the actual unit of selection there was a gene, was really kind of transformational into the way that I thought about particular aspects of biology.

And I've kind of followed that path. Did an undergraduate degree in biology and then a Master's in kind of translational medicine. And it was there where it really fell into the concept of genomic medicine and how understanding precise differences in someone's genome can be absolutely transformational into the way that they are diagnosed, the way that they're potentially treated and managed for the rest of their lives. And so seeing that kind of real life impact for me was an eye-opening experience and is where I followed the rest of my career really.

**Will:** Fantastic. Thanks Jamie. So I think if we start off our conversation with the broader picture in general. We know that genomics has really exploded as a branch of science, and I suppose also of medicine. Then sequencing became faster and more affordable. And Jamie, I wonder if you could talk us through how you see genomics in terms of how it's evolved over the last decade or so?

**Jamie:** Yeah, so I think if you ask a number of people this same question, that'd all come up with different answers. But I'm going try and distil it to two kind of major developments or shifts in the way that we do genomics.

So the first has been technological, and so our ability to generate data for genomes, whether that's humans or other species, has absolutely changed over the last couple of decades. And that's largely through the huge investment from industry, from funders to develop different approaches to be able to survey this really special molecule.

And so nowadays we exist in an environment where there's lots of different choices to do high throughput sequencing or other types of approaches, which, you know, depending on what you choose, can potentially give you different insights into different biological questions. And so, that explosion of technologies that enables us to do high throughput surveillance of a genome is one thing that's really, really changed and that's changed in kind of, in the lifecycle of my own career. And what that's come hand in hand with is a kind of shift in the bottleneck of where researchers sit. So it's now no longer a requirement that there's a whole army of lab scientists generating genomic data. We can do that in a single experiment. And now a lot of the types of research that I do and other researchers do, is heavily reliant upon kind of computational biologists, and being able to process that massive data and be able to make sense of it.

And so I think from my viewpoint, that's the two major shifts, this kind of development of high throughput sequencing technology. And the way that that's changed, the requirement for different types of researchers in this field.

**Will:** And Charlotte, do you think the funding models here have kind of reflected that shift?

**Charlotte:** Yeah, I think with MRC and other public funders, we've put a lot of investment into population level genomic sequencing, through things like Genomics, England, UK Biobank, and following on from Jamie's point, that's given us a huge amount of population level detail, which we now have to analyse, work out what's going on.

**Charlotte:** Some of the other things that I think are important in terms of like investments that have been made specifically in the UK. So whether the UK R & D sector has been quite pivotal - things like Health Data Research UK. a very recent kind of collaborative effort, which I think is a good example of a team-based model for genomics research is, COG-UK, the Covid-19 Genomics UK Consortium - so genome sequencing and tracking variants of concern. It was a UK wide collaborative effort that's had worldwide impact. I think that's quite been a fundamental exemplar of what you can do in genomics. I agree with Jamie. One of the things I'd written down around this, like developments is the increasing sophistication of AI and machine learning approaches that to complement traditional experimental approaches.

An example that we can. Think of recently is in structural biology in alpha fold. So where an open access data sharing resource from structural biologists over a number of decades has enabled alpha fold from Deepmind to predict the structure of proteins based on their sequence. And now we can use this tool to enable prediction of gene variation on, on protein structure.

I think that's a really good exemplar of the sophistication of AI and how that can support genomics research.

**Will:** Yeah, it's such a practical example of it as well. I find it so useful just finding a mutation in a patient and you can just pop it into this protein that you now can guess the structure of, it's amazing. Nicky, more generally then in terms of the evolution of genomics, I think my experience has been the UK has actually been at the forefront of changes. Is that what you've seen as well?

**Nicky:** Yes, a lot of this revolves around the datasets that we've created. Think about the UK Biobank and how transformative that has been and it's only more recently than a lot of other countries are trying to create similar datasets to add more diversity and power to what UK Biobank has kind of paved the way for that. So, you can Biobank along with Genomics England.

**Will:** Can you explain a bit what UK Biobanks are for less experienced listeners?

**Nicky:** Yeah, definitely. The UK Biobank is a massive cohort of around 500,000 individuals, recruited from across the UK and there's a huge amount of, importantly, genomic data on one side, but also linked health data. These people have done a lot of different questionnaires looking at their cognition also about their dietary preferences, there's all sorts of weird questions in there. But it's all also linked to hospital record data and different health measurements. So that gives us the power to do really large-scale genomic studies with health outcome measures. That's been transformative.

And then we are here on the Genomics England Podcast; Genomics England has been a data set that's also paved the way, doing whole genome sequencing on large cohorts of patients. So,we have the population data set in the UK Biobank, we have the the Rare Disease and Cancer Cohort in Genomics England. These are resources that just haven't, until much more recently, existed in other countries around the world.

These have been supported by that funding landscape from, wonderful funders like the MRC, but also government backed initiatives to develop these resources, to get them out there, which is really great. The kind of environment in the UK is a lot about openness and collaborations, particularly within the genomic sphere, that helps us to drive a lot of progress.

**Will:** For sure, that's so important, that's the broader landscape. But in terms of our own experiences over the last, say 10 years, how has it been developing as a genomics researcher, if we stayed with you, Nicky, what are the kind of challenges that you've experienced along your career path? Any surprises or changes in your career?

**Nicky:** I’ve jumped to bat a little bit. I did my PhD in common variation in cancer, in the genome wide association sphere. I was somewhat unsatisfied with this because we were finding variants that had a very small effect on phenotype. And then I jumped into very, very clinical focused, helping set up a diagnostic lab for cardiovascular disease within the Royal Brompton Hospital, and then found my balance somewhere in directly translational rare disease research. So, it's been a huge shift for me. But there's also been a huge shift we talked about in terms of the developments in the field. You basically cannot keep up with the pace of development in genomics, and you have to learn that you're never going to read all the papers.

You get very good at skimming things and trying to get a feel of what's going on and focusing where you think it's most important to focus, but no, it's been a big shift, a lot of development.

**Will:** Fantastic. Has that been a similar experience for you Jamie? I'm particularly interested with what Nicky mentioned about trying to keep up with developments there because I often feel like I'm drowning in articles I'm planning to read and things I'm planning to listen to. Everything seems to move so fast, doesn’t it?

**Jamie:** Yes, I completely agree. Part of that is the change in landscape of the world. We've changed from a predominantly paper-driven journal system where actually you wouldn't necessarily read an article unless you received it in the post, to something where everything's available online and things are available as preprints, as well as sometimes intermediate, so a revised article and then finally as a published article. The massive information that's out there is staggering. Trying to keep on top of all of that is immensely challenging. I set up weekly reminders about papers to read and I don't get emailed about 10 or 20 papers each week, it's several hundred. As Nikki said, being able to streamline which information you choose to ingest and the level of detail that you need to get from that is really quite important. When you know the rest of life catches up, whatever that is, whether that's the meetings you need to be at, the PhDs or the post-docs that you need to supervise, there simply isn't enough time to be able to give justice to all of that information.

I guess one of the things that I think in my mind is quite clear is that, as a generation of ECRs, we're faced with this really quite pioneering opportunity. It's the first time that datasets of this type have been available at this scale, and so being able to find niches and ways to work with that data, whilst challenging and requires often the development of new skill sets, so skill sets that you wouldn't have necessarily got from PhD supervisors or from somebody who's supervising a postdoc, it is forced you to be quite independent. You get that natural progression into more leadership focused roles because you are reliant upon you going off your own back and developing those skill sets. But whilst that's been challenging, that has got immense opportunities because some of the insights that have come from, say, for example for Nikki's data, is truly revelational.

We've understood a lot more about parts of genes that until now, we haven't been able to ask those questions because we haven't had data from a population, but also from disease cohorts at the same scale. Yes, it's challenging. Yes, there's lots of things to do, papers to read, skill sets to develop, but that comes with immense opportunity.

**Will:** Fantastic. That's such an interesting point about how everything is moving so fast that you need to almost be training yourself to keep up with it and that does make you more independent in that your professor probably doesn't know how to use even Archstudio or something like that, so it's always up to you to keep it moving.

One thing that I was conscious of when we were thinking about talking about the last couple of years for early career researchers, is what's happened with Covid and have you seen any problems with that, Jamie? Or transitions in your ways of working? And we might touch on how that affects funding.

**Jamie:** Covid changed life for everyone. In a way, I was quite fortunate in that it was a time where I had a small number of people that I was supervising, and that exploded a little bit during Covid, but almost all of those were computational based.

We're able to connect to the computing systems that they needed to, particularly through Genomics England, providing a remote desktop environment for you to work in. It enabled them to carry on with their work without too much disruption. Of course, you miss the day-to-day interactions, but we were able to keep up with everything.

I suspect that it impacted many research groups much more than my own because being in the lab became a problem. At that point, we were forced into remote working, but we're now faced with the reality where a lot of people in the UK are working in a hybrid way. I actually think in terms of the way that the people that I get to look after and people that I work with closely, it actually works really nicely because you get a good balance between having that flexibility to be able to do a lot of your computational work at home without a huge amount of disruption.

But also, the ability to have those important interactions in person to cement those relationships to perhaps have those more sensitive or more difficult conversations in person rather than through a screen. What I'd be really interested to hear is how that's changed the wider landscape of how people are applying for funding.

I've always largely just applied for computational based grants anyway, that sometimes require a massive data generation, but a large part of that would be people to actually analyse that data, but how in this hybrid world, the landscape of those grants has actually changed.

**Will:** New word, fun scape. What do you think, Charlotte?

**Charlotte:** I'm going to use that new word. Thanks, Jamie. It's a really interesting question. I'm not sure I can answer whether hybrid working and the move towards more computational based working, and I mean like the way people work rather than computational science.

Whether that has changed the grants that people apply for, or whether it's just because there's been that massive evolution in computational science and the technology development there, like broader impacts related to covid. There were lockdowns, limited access to labs. The impact on the clinically vulnerable, we know this had a big ability on certain people's ability to be able to perform research depending on the nature of the research you do. We are yet to see the longer-term impacts on that, especially at the very earliest career stage where you've got a fixed term project like a PhD or a postdoc, and we know it's impacted different people in different ways, whether you had caring responsibilities, particular chronic health concerns, what the nature of your research is. It's going to impact on people's research, track record, and career development, especially at the critical early career stage. It’s important to point out that a lot of the funders we are committed to ensuring that applicants are not penalised for any disruption to their career and projects as a result of the pandemic.

And we're working hard to consider the unequal impacts that Covid might have had on you as a level of assurance on more of the career development, career track record side.

**Will:** Interesting. One of the things you pointed out there was how covid is going to change things in the future, let’s talk about the future more broadly then. I wonder, Nicky, if you could comment on what you think the big changes are going to be coming on the horizon for genomics. You think things like transcriptomics and long reads and that kind of thing are going to be making the big changes or is it more about computational things and artificial intelligence or all of the above?

**Nicky:** All of the above definitely. Multi omics, definitely, hitting things, not just from short read sequencing, but also using transcriptomics. Translatomics is more of an interest of mine, translation of RNA into protein, as well as the transcriptomics being profiling DNA into RNA, and definitely more things to do with computational predictions, machine learning, and artificial intelligence definitely.

From my perspective, I'm fascinated by the non-coding genomes, the regions of the genome that don't directly encode proteins, and we're developing more and more the tools and the data to be able to probe that on a large scale, and we're making strides into our understanding in terms of genome regulation and the impact of that in disease.

And then finally I'm really, really interested in the moving from finding a diagnosis to actually having a therapy. And we are more and more finding the tools in DNA editing and also nucleotide therapies, actually we can start to see a world where a genetic diagnosis can immediately lead to a therapy and that is super, super exciting in my eyes.

**Will:** Of course, one thing that you mentioned there that comes up a lot in genomics obviously is proper data science, coding, all that kind of stuff. And if you are an early career researcher listening to this, who's a wet lab scientist or a clinician, but really wants to get more into the nitty gritties of genomics and informatics, how do you see them as negotiating those changes or what do you think the best steps are for them to add to their skill set? Because as Jamie said earlier, these are the things that often your supervisor can't really help you with because they're changing so quickly, and maybe that's not the environment that they grew up in their career in.

**Nicky:** I, like many people, started off as a lab-based scientist. I started my PhD in the lab. My day-to-day postdoc supervisor was a mathematician, and she said, you'll get along a lot better in this world that'd learn to code.

So, I actually took three months out, my PhD, sat down with a learn to code in Perl book because this was a while ago now, sat there and learned how to code. Later on, in my PhD my supervisor was like, “you've got to go back in the lab”. I was like, “nope, I'm not interested.” I'm far better on my computer doing the data analysis side of things, and I never looked back.

I'd say don't be scared. It's easy to pick up. There are so many online tutorials now. You don't have to do a textbook like I did. So many tutorials on how to pick up the basics of all, even. And it will dramatically improve your life. You'll dramatically improve your understanding of your own data because you'll have the satisfaction of being able to take it from doing the experiments to actually creating, doing the analysis and creating the figure, which is hugely satisfying. Don't be scared. Just give it a go and I'm sure you’ll love it.

**Will:** That's great advice, thanks Nicky. Jamie, what do you think about scanning the horizon and what are the big changes coming in the future? It feels like in genomics you always need to be about 10 steps ahead, doesn't it?

**Jamie:** Indeed, yes. Before I answer that, I wanted to add a little bit to Nicky’s answer because I've got that Perl textbook on the bookshelf that I'm looking at right now. One of the things that's worth noting there, or reinforcing, is that this is done independently in most cases, but there are a lot of courses and resources that you can use to help and assist that learning. It probably shows our age a little bit, sorry Nicky, the fact that we've learnt Perl, which nowadays, if you talk to a data scientist in genomics or other things, actually probably the go-to language is Python. But back when we were learning how to do this, Perl was definitely the hot thing, it was what a lot of ensemble databases were accessed through, ensemble being a massive resource and a collection of data resources for the genome of lots of different species.

One of the reasons and the motivations for learning Perl at that time was to be able to access these databases in a more throughput, a more robust way. But nowadays, people would learn Python or are being able to use the command line. They're all really important skill sets, and importantly, they all exist on a really large continuum.

There can be people that just pick up basic skills to analyse the dataset that's in front of them that they've spent months in the wet lab trying to generate. Through to people who are proper software engineers and will be writing unit tests to test every single line of that code. I don't think it really matters where you sit on that continuum as long as it works for you and it aligns with your future career progressions and what you want to be in the future, essentially.

But in terms of the wider space and where I think genomics is going, I completely agree with everything that's been discussed. I, as well, also have a real interest in a non-coding genome. At the moment, for people who aren't talking about genomes every day it’s quite a staggering fact - about 98% of our genome is non-coding. And currently that isn't routinely looked at for genetic diagnoses. So there are some services that would offer that, but it's not something that we have a comprehensive understanding of how particular changes may cause disease or not. Whereas our understanding of that in the protein code in part of the genome, about the 2% that direct the codes protein, is much more mature.

We have these sophisticated algorithms like AlphaFold that can predict variants that can be particularly damaging. One area that we haven't touched on, that I think is immensely exciting for the future, is making personalised medicine slightly more personalised. At the moment we think about single changes which cause diseases and for example, cystic fibrosis, one of the more common genetic conditions, and we can class particular genetic variants into different severities. But some of the things that I'm trying to uncover in my research is how genomic background, how all the other variants that exist in an individual's genome, of which there may be 4 to 5 million of them, how they actually influence the way that that particular variant that we focused on, that's the driver of disease actually expresses itself.

So how that changes the severity of disease and in some cases, in some really extreme cases, how that can decide whether the disease presents or not. In the future, how that genomic background may influence the types of treatment or management that you actually suggest in the clinic. That, for me, is a really exciting area that I don't think we have a huge amount of knowledge.

So there are some areas where understanding interactions between particular genes is being established and that has direct routes to the clinic. But I don't think that that understanding is completely comprehensive.

**Will:** That's really interesting. I think that also underlines how important it is that we continue to have these large data sets that are shared, say, of cystic fibrosis patients, etc., because it's so hard to figure out these changes unless you have the right data to start off with, isn't it? Talking in general about the way things are going in genomics, Charlotte, where do you think funders want to fit into this? What do you think they're looking at for, in tomorrow's application for molecular or genomic projects?

**Charlotte:** Everything that Jamie and Nicky have said I completely agree with. I'd like to see what the impacts on therapeutics and personalised medicine and pharmacogenomics looks like with all of the new data that we're getting. Something I'm personally excited about is drilling into the causal impacts of genomic variation, so what is the functional impact. Jamie mentioned this earlier, how that impacts cell biology, then how it impacts health and disease. There's been such an explosion in a number of new technologies around functional genomics to really like drill into non-coding and coding, genomic variation and the functional impact it has.

I think we can now ask questions that have been impossible to ask and ask these questions at scale. The other thing I'm really interested in is thinking about where we get our genomic variation data from. So, what populations have we studied in the first place, and then who ultimately benefits from the research that we're doing? There's also enormous potential and need to gain new insights into human health by studying the widest possible range of population diversity. I think some of the efforts that going on at Genomics England, for example, on the diverse data program, that's a really important effort. I’d like to see how that continues to develop.

**Will:** And is that something that reviewers are looking at for in funding applications? Do you think Charlotte?

**Charlotte:** For sure. A new policy that MRC and other funders are adopting at the moment is ensuring that diversity is considered in all funding applications that involve animal and human, more predominantly human participants, both in clinical trials, but also its use of human samples and data. So yes, very much we're going in that direction.

**Will:** Nicky, you're nodding there. Is there anything you'd like to add to that?

**Nicky:** I just want to chime back in on that functional genomics piece actually, because it's something I didn't mention, the exciting things, but actually we're now making strides such that we're going towards being able to make functional maps of the genome whereby we're creating every single possible DNA change across a region and looking at the functional impact of that, these so-called atlas is a variant effect and actually being able to look at the function of a variant that we've never even seen before, before we see it. It's crucial to be able to interpret that when we do see it neither at a patient or the population, which I think a really big area going forwards.

**Will:** I think that's really going to revolutionise variant interpretation for some genes as well, isn't it?

It's just the scale is something that we couldn't have even imagined a few years ago, it's fantastic. Cons, zooming in a bit more on Genomics England, I suppose I wanted to talk a little bit about how we've gotten involved in and how we'd find it to be useful. I first got involved with a hundred thousand genomes, I suppose, as a clinician, recruiting patients. Then when I was doing some research for Diana Belli, who's a Transcriptomic professor in Southampton on a new syndrome. She got me involved in looking at a hundred thousand genomes for new cases and different phenotypes, and we're still finding new cases of that syndrome in a 100K Genomes Project. It's just been a fantastic resource and even today I just put in some requests to contact clinicians for some other new syndromes we found.

I found it to be super useful. How did you involved with it Jamie and what have your experiences been like as a researcher now as opposed to with your lead bioinformatician hat on?

**Jamie:** Sure. I've been in a really fortunate position in that I've been in the right place, in the right seat, at the right time. And it happened when I was doing my PhD, I was based at one of the Genomic Medicine Centres. So, this was an academic centre that was closely affiliated with an NHS Genome diagnostic laboratory and my supervisor was heavily involved in recruitment of individuals to the pilot projects for the 100,000 Genomes Project.

Over what I've seen the past decade, I've worked very closely with researchers who are part of that pilot analysis group. And we fairly recently, about 18 months ago now, published the findings of that. But since then, it's just accelerated. It was almost Genomics England. V 0.01 and it's now evolved to this really sophisticated, well-supported system where I think it's much easier for researchers to come on board to be able to access the data sets.

They want to have all of the software, the tools they want to use at their fingertips. I've seen that ecosystem evolve not quite from day one, but from quite early on. I'm jealous in many ways that nowadays people can do master's projects over three months and actually really start to dive into the depths of the Genomics England data.

Whereas a decade ago, that would've been much more difficult. There was a lot of learnings along the way, certainly from my point of view but that's how I got evolved. And I've never looked back really. I've just increasingly used that data set in my research, and now also in my professional life.

**Will:** Nicky, what has your experience been like in terms of how you got involved in it and what you do in there now in the research environment?

**Nicky:** I was first involved actually when I was doing my postdoc at Imperial College London in cardiovascular disease. I was involved in the cardiovascular group and then when I transitioned to writing my fellowship grant to then set up my own group, the data within GEL, is so unique in the science, the fact that it's whole genomes, that it was crucial to my application and my research because it's crucial to being able to profile the regions of the genome that don't encode proteins. I think one of the postdocs in my team is one of the heaviest users of the research environment. She's asked to test everything, but we use it on a day-to-day basis, have so many students signing up and giving it a go as well. It's really crucial to everything we do.

**Will:** Fantastic. Charlotte, is it important for you when your team is reviewing fellowship applications that they're making big use of these big data sets like Jamie, and Biobank, etc., that they've taught of this when they're doing their applications?

**Charlotte:** Yes, when it's relevant to the research project, obviously. Yeah, yeah. Sorry, sorry.

**Will:** That was

**Charlotte:** That's easy. Fantastic. We want to see that the UK public sectors put a huge amount of investment and other funders into GEL and UK Biobank, for example. We want to see that they're being well used and also in being used, there's constant improvements and questions being asked and then new functionality and new funding, new abilities can be added onto those initiatives. So yes, absolutely.

**Will:** Certainly, from my perspective, what Jamie has said has really chimed with me that it used to be a lot less user friendly, clunky, and more likely to crash. But in the, especially in the last two years, I've noticed a massive improvement in the number of tools available.

Lots of point and click stuff if you're not too good at coding. So, I'd really encourage as many clinical researchers who maybe are uncomfortable with data to give a go at the moment. It's really been fantastic for me. I suppose more broadly in terms of what GEL is offering early career researchers, I think everything is changing so quickly with genomics.

It's both very exciting, but also maybe a little bit intimidating at times. And there's been a lot of moves recently within Genomics England to try to make life easier. For early career researchers and to develop more offerings in terms of accessibility and training to make ECRs, I suppose, more engaged.

That's something from the GECIP side that we're really keen on and pushing. So this is in its early stages, but we'll have a link in our show notes to the webpage where we display all of our researchers for early career researchers. And I also wanted a flag that we'll have an early career researcher session happening at the Genomics England Research Summit, which is coming up soon.

We've had lots of different seminars going on over the last year or so, many of which are led by early careers researchers talking about the amazing research that they've done within the research environment, which has been published in some of the biggest journals in the world. That's a fantastic thing for you to get involved with but also, just listen to, because there's so many inspirational projects there that will give you ideas and give you an idea of the scope of things that can be accomplished within the RE. We've also got lots of blog posts available on the Genomics England blog. Myself and my colleague Leticia, who is a young bioinformatician, are involved in the GECIP board and happy to be contacted about any queries or suggestions or improvements within 100K.

There's lots of training sessions available, which can be accessed via our website and there's also a mailing list to sign up to be alerted to these. We'll wrap up there. Thank you to our guests, Nicky, Charlotte, and Jamie for joining me today as we discussed how ECRs navigate and position themselves within the ever-changing field of genomic research.

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