Brain Stories Episode 4

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alzheimer, disease, people, ageing, brain, dementia, families, therapies, research, thought, pathology, ucl, amyloid, stories, nick, familial, absolutely, differences, gene, spent

**SPEAKERS**

Caswell Barry, Selina Wray, Nick Fox

**Caswell Barry** 00:01

Hello, welcome to brain stories. I'm castleberry and I'm here with my co host Selena Ray on brain stories, we

**Selina Wray** 00:06

aim to provide a behind the scenes profile of the latest and greatest work in neuroscience, highlighting the stories and the scientists who are making this field tick.

**Caswell Barry** 00:16

We don't just ask about the science, we asked about the scientists and how they got to where they are today, where they think their field is going in the future.

**Selina Wray** 00:28

Today, we're delighted to be joined by Professor Nick Fox, Nick is a professor of clinical neurology, and he's the director of the dementia Research Centre at UCL and Professor Fox, His research interests are focused on the early detection, differential diagnosis, and the monitoring of progression in cognitive disorders and neurodegenerative dementias. Nick, welcome. Hello, thank you so much for joining us today. Oh, thank you for asking me. So I feel like this was the episode that I've been looking forward to recording because it's the first one we've done that will really have a disease, focus, and energy, no, I'm slightly biassed. This is an area that I'm very interested in myself. But I wonder if we could start off by hearing from you, in your own words, what your research is focused on and what your areas of interest are?

**Nick Fox** 01:20

Well, my research is quite clinically focused. So I've been very interested in how we detect the earliest changes of diseases like Alzheimer's disease, how we track progression. And that's not just for its own value, clinically, or for helping families with prognosis, but also, so that we can accelerate the search for therapies improve clinical trials, if we can track changes that are not just clinical, but are, for example, changes on brain imaging, how the brain changes, and then there's an opportunity to see whether the disease can be slowed. So that's been interesting. An element of my research has been on this amazing group of credibly committed patients who've got familial dementias.

**Selina Wray** 02:13

So how common is that? Just for the listeners who might not know as much about dementia? Is it? Does it often kind of run in families?

**Nick Fox** 02:22

That's a great question. Because nearly everybody now with ageing populations, nearly everybody will have somebody in their family. And that causes a great deal of anxiety. So I'm not really talking about those sort of families were great answer, and so had Alzheimer's disease in her 90s. I'm talking about families where there is truly autosomal dominant inheritance. And what I mean by that is that the gene is passed on and is dominant. So if you just get one copy of the gene, you will develop the disease, and typically, the diseases incredibly early, so you can get Alzheimer's disease at age 30, or 40 or 50. So decades earlier, than the Alzheimer's disease that were normally expecting people to develop in their later years. It's quite

**Selina Wray** 03:12

remarkable that people we don't typically think of people developing Alzheimer's disease in the 30s. And I think there's still kind of a misconception, I would say in kind of, generally, that it's a disease of older people, and perhaps an inevitable part of ageing. And is that something that you still feel persists? Or do you think that the understanding of Alzheimer's disease outside of the scientific community is shifting a little bit?

**Nick Fox** 03:42

I think it is shifting. I think there are still lots of awful myths out there. And Alzheimer's disease diseases used interchangeably with dementia. And Alzheimer's disease is just one of many conditions, many diseases that can cause dementia. I mean, you see this even in, in actually in pretty reputable media that that mistake is made. I think, the idea that it's just an inevitable part of ageing, I think does still persist. I think that's changing a bit. I think there's more of an understanding that these are truly diseases and that while they are more common with ageing, they're not caused by ageing. And, and of course, those rare autosomal dominant young onset cases they are the minority because the majority of diseases like Alzheimer's disease does affect people in their 70s and 80s. And, and later, so there are only a few 100 families perhaps. Yes, perhaps several 100 maybe less than 1000 families with familial Alzheimer's disease in the UK. So that has to be set against an estimated 800,000 people with dementia of all sorts and of all ages, but mainly in later years.

**Caswell Barry** 05:11

And then I'm far from an expert on outsiders. But I'm curious what you sort of think the future of sort of addressing Alzheimer's is, is it a war or dementia in general? Is it about lifestyle changes? Is it exactly what you're saying? Here? It's, it's not a sort of genetically pre programmed disease, or at least as far as we can tell? So is it addressing people's lifestyles in their earlier life? Or is it management? Or is it just sort of straight up sort of medical treatment? Or is it a combination of all these?

**Nick Fox** 05:38

Well, it's a combination, I think, I think there's things that we can all do, that reduce our risk of dementia. And some of that we need to do at quite an early stage in middle years. Some of it, of course, it's stuff that we all should be doing anyway, for other reasons. You know, smoking is not good for your brain, high blood pressure is not good for your brain, poorly controlled diabetes is not good for your brain, she's not good for your brain to, to go and have a few rounds with mommy, Dolly, that's not good. So, so trauma and some of those vascular risk factors, they're just not a good thing to do. Though, you know, people obviously persist. But we are reducing, to some extent, the burden of, of that disease, with better public health and better control of people's blood pressure, that's shown a worldwide reduction in age specific incidents. But it's only a part of the, of the that that combination of genetic, environmental and things we don't know that cause this, these diseases, and diseases like Alzheimer's disease, I do not think will be simply prevented by lifestyle changes, that that makes some marginal differences, important difference, and we should all be sensible about those things. But that's only chipping away at the edges. I mean, what we really need to do is have effective therapies, and diseases, like Alzheimers disease, that have been thought to be incurable, are now curable, or at least have got ways of managing Well, number of the cancers, HIV AIDS, we've got real transformation in our therapies, I think a really interesting component to disease like Alzheimer's disease, is it may be that we have to intervene much earlier. And if our research and many others have have contributed to the idea that and the recognition that Alzheimer's disease has changes in the brain 20 or more years, before you get symptoms. And so we will need therapies that work at that stage. And we'll need ways to identify people at those stages. But that may be our greatest chance of really effective therapy

**Selina Wray** 08:02

and the rare familial forms of Alzheimer's that you've spoken about have really been instrumental into the progress that we've made in in kind of those arenas. Can you tell us a little bit more about what we have learned from familial Alzheimer's that has informed our knowledge about Simons as a whole?

**Nick Fox** 08:21

Yeah, they've absolutely been instrumental. But But, but before I tell you about the science, I think I need to mention a bit about these families on a on a more personal level. I started doing my research thinking I might do a clinical PhD and do and then go back into clinical neurology finished my training straight off. And I my research project was about familial Alzheimer's disease. And these families are amazing. They are incredibly brave, they're incredibly generous, and they have an awful prospect ahead of them knowing that you're I don't know that your mum had Alzheimer's disease at 40. And often having lived with somebody as a child, I mean, the stories dreadful of children who cover up for parents and don't admit that they haven't done their homework because actually their mums lost their schoolbooks. And then people who have the 5050 chance hanging over them because also more dominant everybody. You know, any any child or somebody with familial Alzheimer's disease has a 50% risk. And people then make individual decisions about whether or not to get genetic testing, whether or not they want to have children themselves, what all that means. They're amazing families. And if Have you heard anything to motivate you? You meet those families. And, and they have given so much we, you know, it's it's it's no exaggeration to say we've understood about the pathogenesis of Alzheimer's disease. We've developed the hypotheses for its aetiology from these rare genetic forms. And now, we are not only getting an insight into the pre symptomatic elements, because we can follow people at risk, and they generously contribute to research. but also those families are taking part in clinical trials, which seek to slow the disease.

**Caswell Barry** 10:40

And are they I don't know if this is sort of controversial view or not. But is it? Is it possible that Alzheimer's sort of captures actually a sort of a broader spectrum of maybe sort of similar but slightly different pathways to the same outcome? Is there any chance that the sort of familial families have something have sort of a different pathway or differences that might mean that they're not as good a model as we think they are? Or is that sort of a settled question? Oh, no, it's

**Nick Fox** 11:08

far from settled. And, you know, there's a school of thought that says we shouldn't be referring to Alzheimer's disease, but we should be referring to Alzheimer's diseases. Because of course, we have different phenotypic expressions with Alzheimer's disease, not just that somebody can get at 50 and somebody else can get it at 80. But how people's Alzheimers disease defined by a pathology in the brain manifests them in them cognitively, behaviorally and their their functional impairments, differs from person to person. But you're absolutely right. One of the starkest differences is those people who were there is an autosomal, dominant inheritance, and they get into 30 or 40. But the similarities, I think, outweigh the differences at this stage. Yes, maybe we will know more about how these, there are multiple different pathways. And we certainly have a have a bit of a sense that some of the key proteins are involved a balance between overproduction and, and a failure of clearance. And it may well be that these young onset genetic cases are predominantly an overproduction of the pathogenic protein, and very late onset may be overwhelming a failure of clearance. But you can't have one without the other.

**Selina Wray** 12:33

So I think it's, I mean, it's amazing how much these individuals have chosen to kind of show commitment to research and really supporters. I mean, as you know, Nick, I've had the pleasure of kind of meeting several people who participate in research, and indeed, they've contributed to my own research. And one of the things that I always quote, when I give give talks is this idea of we're making progress, because within several generations, we've gone from being able to say, We're really sorry, we know this is in your family. But we don't know what the causes, too. Well, we know that this is the gene that is causing your disease, but we can't do anything about it to actually we can put you into this clinical trial, if you will, you're wishing to participate. So what's the current status? Do we have reason to be optimistic about treatments for Alzheimer's? It's obviously been all over the news recently with the approval of aggi. County map. But that is one of just many kinds of therapies that is in in the experimental pipeline. And how do you feel looking forward? Is it a time of optimism?

**Nick Fox** 13:40

I think it is. And I have to say that with some reticence, because I've been telling families, that we're making massive progress. And it will be a few years and there are promising therapies in the pipeline. And while that was true, in the two decades, I've been saying that we haven't come up with an effective therapy really, I think, can the risk of sounding like I'm saying the same thing. Again, I think we really do know a lot more and we do have promising therapies. One of the things about the last few years of therapeutic trials, while we haven't produced a really significant, we certainly haven't found a cure and clinical benefit has been really hard to achieve. slowing of cognitive decline has been honestly marginal even for those therapies which seem to show show benefit but being symptomatic or disease modifying, but we are now shifting pretty clearly pathologies. We've got mechanisms to alter the pathology in the brain. And that is a step forward. We are with these new therapies. We are clearing amyloid from the Brain. Now, what does that mean in terms of translating into downstream effects and in terms of neuronal damage and neuronal death, and then cognitive impairment? We don't know the jury's out. But we are shifting pathology and we are understanding those pathologies bet. And ways in which we can interfere with a poorly understood process. But at least partly understood.

**Caswell Barry** 15:31

That's really, I find it really interesting what you say about there being a relatively little progress of two decades. Where's the sort of? Where's the failure? Maybe failure is a strong word to say, but is it? Is it our understanding? Is that the theory that isn't just being born out? Or is it is the theory solid, and we just can't find therapeutic drugs that have the effect we want? Like, where's the I'm curious, where's the sort of? Where's the break in that chair? It's

**Nick Fox** 15:52

a great, it's a great question. So if we think about people often say it's two decades, it's 20 years since the last therapy for Alzheimer's disease was was licenced. I think that that kind of misses the point. Because the first is, we're essentially recognising that there are neurotransmitter deficits in the answer in my brain. I mean, I don't want to simplify it. And it was a great step forward, but but you can, you can find whether or not neurotransmitters are reduced in an Alzheimer brain compared to a normal brain, it with techniques that were understood 2030 years ago, and then you can think we've got lots of diseases where we can boost neurotransmitters in the brain. We do that all the time, you know, treatments for for depression treatments for Parkinson's disease. So those were the first therapies. But it's a completely different challenge, to interfere with a pathological cascade. Rather than just boosts neurotransmitter. And this isn't a sort of plea bargain type of of statement about, you know, please forgive us because it's a difficult disease. But it is has been a difficult disease. But it's also lagged hugely behind cancer and other major diseases in terms of it's the investment in research. Now that's catching up. And that's also a cause for optimism.

**Selina Wray** 17:23

And your research, Nick, is spanning kind of quite a wide range of approaches to understanding outside master of none, is that what you're saying? Would I absolutely not? And no, I actually think you're in probably better position than anyone else we could interview to maybe speak to, where's the most excitement at the moment, because you've talked about the need for a lot of different areas to progress in parallel for us to get to where we need to be. So trials are no good unless we know who to give them to. We won't know who to give the drugs to unless we can diagnose as accurately and as early as possible. What's happening in kind of your world at the minute that you think, yeah, this is the most exciting thing.

**Nick Fox** 18:11

So I think we made phenomenal progress in an area where we were way behind in terms of biomarkers and understanding of pre symptomatic phase and knowing how to detect disease early and track. So I think while that problem is not solved, we have made great progress. We have got markers of specific pathology, imaging, CSF and blood, whether it's markers of amyloid or of downstream effect of of amyloid be phosphorylated, tau in your generation, your filament life, lots of things where we've made great progress. The the area that that so we know we can identify people, we can identify a window of opportunity where we can intervene early. The real challenge is, is those effective therapies. And I do think that the door is starting to open with therapies that are showing we can change pathology. I'm quite excited by the opportunity. As of course, you know, Selena from work we do together about in our families, that whether we can interfere with the the upstream with the gene itself, its gene or its product that really feels like we really would be addressing the known cause in these families. And I think some of these other approaches. I do think that the ability to really remove amyloid, certainly if it was applied early enough, I think that has been dismissed by many as being too early to be dismissed. I think there is potential there. But the challenge is finding a therapy.

**Selina Wray** 19:59

Yeah, no. Absolutely. And it's, I think there's a remarkable statistic which think I might have heard from you, Nick about, even if we could just delay the onset by five years, the impact that that would have on people's life on the economy would just be remarkable. So

**Nick Fox** 20:16

notice, the statistics of are, are amazing about when you start looking into this. They're also slightly shocking. So dementia court costs the UK economies something like 26 billion a year off the amount that dementia costs cost the economy, much less than 1% is spent on trying to stop it or solve it. So less than 1% of the cost of this devastating problem is spent on research on trying to find a cure. You know, it's, you know, what other problem, it will be like, no, the COVID pandemic plucking something out? Yeah, right. Okay, we've got we're going to spend all this money on isolating people. We're going to spend all the money on, you know, more PP, you know, protective equipment. But But shouldn't you find the vaccine to?

**Caswell Barry** 21:25

Do you think I mean, we've, at the beginning, you said that it's easy for people to sort of conflate Alzheimer's disease with all other dementias. Other things we learning about outside has been through the research into Alzheimer's? Do you think those will carry across to other dementias? Or will we have to sort of start from scratch on on those, I guess what I'm saying is always sort of also getting free basic science into the bargain. And we're definitely

**Nick Fox** 21:47

getting free basic science, we're definitely getting free basic science and there will be some things that will carry across, but I think disease modification, need us to understand and intervene in a very specific pathological process, there are a number of things that will, will absolutely cut across diseases, they will be techniques they will be and conceptual advances, there'll be an understanding of, for example, there is a pre symptomatic period, what we seen in Alzheimer's disease absolutely occurs in in many of the other neurodegenerative diseases, the approaches, whether it's a gene silencing approach that we'll have, we'll cut across. And, and of course, we need, one of the challenges, of course, is getting therapies into the brain. And that will be common to all of the brain disorders.

**Selina Wray** 22:44

fascinating stuff, I wonder if we might switch focus a little bit next. So the other part of this podcast is as well as hearing about the science, we like to talk a little bit about the person. And so how did you end up working at UCL on Alzheimers disease? Was this was this part of your destiny from childhood? Were you from a family? Right? This is where I've got to go with my life.

**Nick Fox** 23:10

No, no, no Far, far from it. You know, I mean, all of those people who age seven know that they want to be a brain scientist or an engineer or whatever they want to be I had no such set commitment or, or destiny ahead of me at all. No, no. Much more opportunistic and never knowing really what I wanted to do. So I had quite a different sort of approach didn't come from a medical family. I grew up in in Jamaica, and school, particularly seeing kids in the UK going to school was pretty relaxed. So you know, long holidays, short days. Not much homework. It sounds it. Certainly say to me, but partly as a result of that. I don't, I don't think I was I found maths and science easier. writing essays sounded like it seemed a lot of work. So that's how I ended up doing that. And then when it came to, to thinking about what I would do at university, I, again, Pauline informed by I guess the the times that I was growing up in but also my background is I thought I would go to university and I would do natural sciences, engineering, and I would save the Third World by alternative energy. So this was my with a wonderful naivety over an 18 year old that that we all have that great confidence and born of of have built confidence out of out of innocence and naivety perhaps, but anyway, that's what I thought I would do and I did a science degree and

**Selina Wray** 24:59

came back to the UK for your degree,

**Nick Fox** 25:02

I came back to my to the UK for my my degree in natural sciences. And actually I got quite interested in some of the other natural sciences as well. And physiology was very interesting to me. So I did make my main focus was physics, partly from that original aim and just because what I was good at, but I thought physiology was really interesting. And again, for those people who are feeling that they don't really know where they want to go, and how, you know, I, I have a lot of empathy for them, because I did my degree, and I got offered a PhD in essentially alternative energy. And I thought, three years, Kaushal three years of research, I had the old By that time, I wasn't really sure I could commit to that. So I wanted to do something before doing that. And I also had a slight inkling by them that actually, some of the physics research that I've been seeing in my undergraduate years, made me feel like that was a fair way away from people. And so I went off and did various other things in the meantime, but then thought actually, combination of physics and science and, and unliking talking to people. Maybe medicine was the right thing. So I went back and did did medicine. But the irony of it all is of course that I've ended up doing years of research that my that my former self would have thought really.

**Selina Wray** 26:48

So when you say you went and did other things, Nick, I have to probe that a little because we've had two previous guests now I think that had slight detours in the music industry and thought they might become kind of world famous musicians. Is that was that your detour as well?

**Nick Fox** 27:06

Anybody anybody's heard me sing would know that that would be incredibly unwise. No, absolutely not. I, I really wasn't sure what I wanted to do. And actually, I spent, I saw an advert for an applied for a job in the Foreign Office. So I spent some time again, thinking that maybe my experience of having lived lived in somewhere like Jamaica, and, and having an empathy for those sort of issues would be relevant. So I worked in the Foreign Office for a while before doing medicine. But But they've been various other details on the way partly to fund myself through medicine, but also because other things interested me as I went along,

**Caswell Barry** 27:54

would it be fair to say? To what extent do you think you pick things up along the way? Are there other things, your physics degree in some in the foreign office that you you can relate to in your sort of day to day life as as a research scientist? Or is that just a block of time that's behind you?

**Nick Fox** 28:09

I think I think that sort of the physics was helpful, not particularly because of that gave me a phenomenal, you know, understanding or anything. But it, it meant that I both had some credibility on grant applications, rightly or wrongly, when I first started because I was doing MRI magnetic resonance imaging of the brain. So you know, whether it's true or not, it gave the appearance that I might be able to understand what was going on. And perhaps it also gave me a bit of confidence that this wasn't a completely impossible world to try to understand. I think that that's held. And it would be far, far from my place to say whether or not what the foreign office does had any relevance to a complex bureaucratic hierarchy like universities.

**Selina Wray** 29:14

And so what made you ultimately end up at UCL then, it seems to, you know, it now is a hope for dementia research. It's, it's, you know, one of the priorities I guess, of the university, Has it always been like that? Or is it something that you've kind of seen growing your time here? And, you know, did you did you come here because you saw an opportunity to develop that? Or was it because it was the best sense to be

**Nick Fox** 29:40

you give me again, far too much credit Selena for any any sense of direction or purpose, or commitment. Again, it was opportunistic. So as a junior doctor, I asked you do you work through different specialties I wasn't sure what I wanted to do. And still harking back to my background, I slightly thought that if I did do some specialty, I might be thinking about doing something like public health. And then I did a job at the National Hospital for neurology at Queens square, which is now very linked to UCLA, or part of UCLA and linked to UCL. And I found neurology in the brain interesting. And particularly dimension cognitive decline, something that seem to be both important and, and interesting. And then a former boss who worked for the National Hospital set, oh, I'm the Alzheimer society, have just announced clinical fellowship. So I think, you know, using your physics background, we could put in something to do some brain imaging with MRI or something. And so I said, sounds good, but I'm not really sure what I want to do. I'm doing a busy ICU job at the moment, I really haven't got time to think about. And he said, Well, no, we'll just put it in, we can always pull it later. And the next thing I knew I had had an interview, and then had to have the embarrassing position of in the interview, it being clear that I didn't know anything at all. And they plumbed the true depths of my lack of knowledge. And I do wonder whether the physics may have been the, the, the thing that helped me get that first fellowship from the Alzheimer society, and then I, then the rest, as they say, is history because I became interested in it. And I got lucky with a few things during my research that just went well, and, and then that led on to other ideas. And, and one thing led to another, but UCL in the time that I've been involved, has really, really strengthened its dementia, built on good, long standing neuroscience. But I think the sort of dementia research, which initially, I mean, the ivory tower, neurologists originally used to think that diseases like stroke and dementia were rather beneath them. And that was things that other doctors could deal with. That's changed, thank goodness, I guess I would say that for for people going into the field, to think about a disease, or our area or research where there is a real need, I think that absolutely extends to the brain and dementia in neuroscience. And, you know, you don't want to you want to don't want to don't want to work on a disease that's kind of being cured and going out of fashion. And that's certainly not the case for dementia. So I think there's a plea to people to actually this is a good place to work. This is somewhere where there are remarkable advances happening. But we're still at a steep part of the learning curve. And it's a problem that, sadly, is not going away. And it's definitely commands the attention of governments and funding agencies who think this will bankrupt health and social care. And maybe we should be spending at least 1% of the cost. That is one of the assets that I and a few others and some courses wrote for the for the g7 summit or g8. It was then on when they did dementias. If countries could commit just 1% of what it cost there, then we would really get a massive acceleration in research.

**Selina Wray** 33:41

We need as many many hands make many hands make light work, right? We need as many people working on the problem to solve it. We need to beg, borrow and steal things from other fields.

**Caswell Barry** 33:52

Or although as a sort of outsider looking in from what you're saying here, this sounds sort of it sounds fantastically optimistic. I mean, maybe you're just a very optimistic person. But it does sound like you know, we're on the we've traversed the plane of understanding. And now we're on the foothills of I don't know solving it. That's very poetic. It didn't sound

**Nick Fox** 34:12

good. I think I'm probably I'm pathologically optimistic. Most of the time.

**Selina Wray** 34:18

It does feel a bit like that, though. I mean, as someone, obviously I can speak to this because I'm in the same field. But in the time that I've gone from being kind of a PhD student to PII, there are genes that we didn't know existed. progranulin was discovered when I was still a PhD student, and TDP 43 inclusions. They were unknown when I was a PhD student and you kind of see these huge leaps forward, and it's knowledge that we take for granted now, but it's actually still really new. So I think, you know, I think it's good to kind of have that perspective when you're kind of really deep in experiments and things not working in your sole focus to kind of have a second to take a step back and think well, I Actually, even in the short time that I've been in this area, there have been huge leaps forward in knowledge. And so yeah, it does, it does feel really exciting.

**Nick Fox** 35:09

And those those leaps, I think, will make a real difference because they're, they're No, they're not arcane, esoteric bits of Oh, well, this is how this bit of the brain works. There are fundamental to these disease processes. And the course it's really important to understand how the brain works and, and all that but but to make a difference, we need to understand these pathogenic processes as well.

**Caswell Barry** 35:35

So next, we ask all our guests at the end of the interview, the same question that question is, What is your favourite fact about the brain? This can be as as wacky or serious as you like, oh, my goodness, how do you how do you there are so many facts? Okay, as Selena will know, some of my research has been done on using techniques to them, right to measure brain volume changes,

**Nick Fox** 36:01

we have this thing that that makes us the thinking human that we are, which is just over a litre in volume 1.2, maybe, and every minute, almost a litre of blood gets pumped to that brain, almost its whole volume gets delivered, just to support it. Isn't that phenomenal? Can you imagine, you know, if you just think about yourself as a human, you taking a litre of, of liquid, maybe you might take in two or three litres over over a day. But the brain is being supplied by almost half its volume, every minute of blood just to sustain it. That's amazing fan. And another one, too, for the price point by being greedy here. So Alzheimer's disease and these other degenerative dementias, you lose brain volume year on year, and you lose it at a much faster rate than you do in normal ageing, I'm afraid we are all losing brain volume. So that's another fact. Point 2.3% in our 30s 40s and 50s. But but it's 567 times that in Alzheimer's disease at whatever age. But if people have we did a small experiment looking at the effects of putting a real osmotic challenge on the brain. So people are going for dialysis, renal dialysis can have a 3% volume change in the same day. So they can have a change in their brain volume. That's equivalent to the amount you might lose in Alzheimers disease in a whole year.

**Selina Wray** 37:45

Nick, that was a really fascinating discussion. I think I could talk to you all day. But we should wrap things up. And thank you so much for joining us on this episode of brain stories. And we look forward to seeing you all next time.

**Caswell Barry** 38:01

We'd like to thank Matt wakelin Maya Sapir Trevor smart for their roles in taking brain stories from an idea to a fully fledged podcast, Susie McCarthy for editing and mixing. Follow us on Twitter at UCL brain stories for updates information about forthcoming episodes.