Your Complex Brain – Season 3 Episode 6 – Are Reading Disabilities Genetic?

Dr Cathy Barr 00:01
[Your Complex Brain theme music] Not being able to read in this society can really affect your livelihood, your ability to provide for your family, your thoughts about yourself, your mood. It's really important to get help, at however level you can get it.

Heather 00:23
[music continues] This is Your Complex Brain, a podcast all about the brain, the diseases that impact it, and the path to finding cures. I'm your host, Heather Sherman, and I have the great pleasure of working alongside the team at the Krembil Brain Institute in Toronto, Canada, a leader in brain research and patient care. In each episode, we'll take you behind the scenes into our clinics and research labs to meet the game-changers of the future. We'll empower you with the latest research to help you take charge of your own health. You'll also hear from people who are living with brain disease, as well as their loved ones and the care teams who support them. Join us on a journey to unravel the mystery of your complex brain. [theme music continues then fades out]

[delicate, rhythmic electronic music] Do you know a child who has difficulty spelling or sounding out words? Maybe they feel stressed or anxious when it comes to reading or they try to avoid it altogether. These symptoms could be a sign of a reading disorder, which is the most common form of learning disability. Today, we're going to talk about the prevalence and impact of reading disorders, what scientists are learning about the genetic links, and what that could mean for new approaches and treatments in the future.

[music continues] But first, we'd like you to meet Matthew Côté. He was once one of those struggling students. Matthew now works as a teacher, inspired by a teacher in his own life whom he says helped him realize his true potential. Here's Matthew's story. [music fades out]

Matthew Côté 02:02
[bubbly, pensive electronic music] My name is Matthew Côté and I am a person with a learning disability. My disability impacts the areas of my brain around phonics and phonological processing, which impact how your brain decodes and encodes different letter sounds, so breaking down the sounds of a word to blend them together to make meaning is something I struggle with. Because I struggled blending letter sounds and decoding and encoding words, I really struggled in my early years with reading and writing. And so, as the kids around me were starting to learn basic words, basic letter sounds and combinations, I very much struggled with that and, really, for me, it took all the way to, like, grade six, seven, and eight before I was reading independently.

[music continues] Because of that, I was a very anxious kid because, while other students may be able to find their way home after school, I couldn't read the street signs. I had things memorized. I could really navigate the world through memorization or through what I was comfortable and familiar with, rather than being able to read to access new information and access new things. At recess, when my friends played Pokémon cards, or Yu-Gi-Oh!, I couldn't play with them because I couldn't read the rules. I couldn't actually engage with what my peers were doing, and so it really was a big struggle because I grew up feeling very isolated and alone because I felt like I was the only one who couldn't read. I was the only one that was struggling with this.

[music fades out] Help arrived when I was in grade five. I was diagnosed with my learning disability then and I got my first piece of CEA technology – the government technology to school boards for students with disabilities that need other tools to help them with their learning. Mine came with a program called Kurzweil, and it was a text-to-speech program, so it would read things to me, and I remember that my mom, who was a big help in my life, got me a tutor, and she made it known to the tutor that she wanted me to do all of this with my technology for the first time, and it was hard. It was probably 20 or so hours on a fifth-grade project—more than you would think—but that was due to the speed that I needed to read everything in and learning how to use my technology for the first time. And I would say, at 10 years old, 11 years old, that was the first project I had that really actually showed what I knew because then I could actually fully read and understand. I could work with my tutor and she would scribe or type and help really capture all of my thinking because it's that encoding piece too of putting those letters together to form words, to write things out.

[music continues] And so, school was really frustrating until I got my technology because I knew what the writing meant, but unless you spoke Matthew, you didn't know what it meant for yourself. And so, it was very hard for me. I was like, "Wow, even though it took a long time, I have something that I can actually look back on and be proud of," and it really helped me start to believe in myself and start to accept my own differences. Even if I didn't still, at grade six, know why or how I was struggling with these things, it was evident that they helped me and it was nice to have somebody that didn't want to make me feel different for it. [music fades out]

[upbeat electronic music] A big part about it was up, until that point in my learning experience, I didn't ever feel like I fit in with the other kids with learning. I knew I was struggling. I knew I was behind. I knew I didn't have as easy of a time. One teacher that made a difference in a big way for me would be in grade 8. My teacher, we were doing projects and I don't know if he did it because of me, or if it was just a project that I really resonated with, but we had to do PowerPoints with no words. We had to research a global issue and present it to the class, but with animated PowerPoints on it. So, it was like cool learning that we had to do, but it played right into my strength of presenting and talking and not relying so much on that reading component and that research and that typing. Anything I needed to write or say, I could make little bullet notes for myself and just anchor my presentation around that, and he would work with me after school or before school and he would do that with all the students, and so it didn't feel different. I didn't feel other. It wasn't about going out of the room to get help. Help was right there for me.

And, even at that age, when I'm struggling to read and write and navigate the world, having those people there to help support me and help believe in me made a huge difference. I am 27 years old right now. I'm currently working on my master's at Ontario Tech University and any longer text, I still struggle to read and decode on my own. [music fades out] [gentle electronic music] The way that it was explained to me by the psychologist, when I got my second assessment at 17, was by the time I finished reading a sentence, my brain has spent so much energy decoding each of the words to say them, to pronounce them, or make what that word is, at the end of the sentence, I have no meaning.

I excel at listening. I really rely on Google Read&Write to read to me as I follow along and that is a piece that I've learned as I've grown up, too. I can't just listen. I have to be following along and watching as it goes because it kind of highlights as you read and I still use it every day because it still impacts me in my life.

[music continues] Today, I work as a supply teacher with the York Region District School Board for K-8 students. Going through school, I felt very alone and I didn't want other students to feel the way I felt when it came to their experience in school. I was the kid that sat alone on the playground, I was the one who watched the other kids play games, and the one who knew they were different but didn't know how to tell somebody why they knew they were different. And it was for more than one reason but, when it came to engaging with my friends, the biggest part was I couldn't read and engage with the same things they did. [music fades out]

[glitchy electronic music] When I started to do better in school, when I had my assistive tech, my mom actually got me to come and speak at her schools, at her staff meetings as kind of like a, "Hey, students with learning disabilities can achieve," and that started my work in advocacy and that started to make me see, as teachers realized my story and my success and made them believe in their own students, I was like, “I want to do more of that. I want to help people believe in themselves and believe that they can achieve, even if their path to achievement looks different," because my path looked different, but I'm still making my way through, and I feel very grateful to be able to have gotten to where I am because of the people that I've had to support me.

[music continues] My mom has always been my biggest advocate. I remember I would come home from school in elementary school and we'd have a writing assignment and I would just be bawling with my mom and she really had to help teach me how to chunk assignments, how to break things down into parts and steps, and teach me that, even if I'm overwhelmed, I gotta start, and that's something that I take with me into being an adult and into being a teacher now that, we gotta start. It doesn't mean we have to finish today. And it's about overcoming that anxiety and that worry, that fear, and knowing that it's going to be okay. If I didn't have that then, I wouldn't be where I am now. [music fades out]

[soft electronic music] When I take jobs in classrooms and I go and I'm supporting kids, they often let me know what students may be on technology and things like that, and so I often disclose, typically, to the whole class, as soon as attendance comes out because I have to read a bunch of names that I don't know how to pronounce. So, when I disclose to the class that, "Hey, I have a disability in reading. It impacts how my brain breaks letter sounds, so if I say your name wrong, I'm sorry. Tell me how to say it," and that typically gets us off to a good foot.

Students have come up to me themselves and they either disclosed, "Oh, I have a hard time with reading too. I'm not so good at it," and it starts a conversation. Recently, I had a long-term occasional position and one of the students there had dyslexia, and when they found out that I had a disability myself, they were blown away. They couldn't believe it. They're like, "What? And you're a teacher, and you've made it here?” And I remember the parents coming up to me and saying, "You're the first teacher who makes them feel seen. You make them feel like they have a chance, and there's so much they can do. They'll run marathons for you, Mr. Côté." And I'm like, "I'm not asking them to," but, like, that's heartwarming to feel that you've made just a difference in somebody's life by being around, being who I am, and disclosing to them and sharing with them some of my own struggles.

I hope that I get to continue to do that as I go through teaching, that I get to meet students, let them see that it's okay. You've got to find strategies and the tools you need to help you, but you're going to be able to achieve whatever it is you want to achieve. [music fades out]

[bubbly electronic music] I want them to know that reading is one way we engage with the world around us, but it is not the only way. There is so much to be gained from connection and talking that we

can't discredit those in somebody's learning, as well. There are so many ways we show learning. There are so many ways we engage in learning, and just because one part is hard for you, that shouldn't be a reason to disengage from it or feel like you don't belong in it. Everybody belongs in learning. Learning is something that's for everyone. Find the tools you need to help you with learning and don't be afraid to use them. [music fades out]

Heather 12:22
[Your Complex Brain theme music] I am thrilled to welcome to the podcast two of the leading experts in this field. Dr Cathy Barr is a Senior Scientist with UHN's Krembil Brain Institute and the Hospital for Sick Children. Her research focuses on genetic links to neurodevelopmental disorders such as childhood depression, Tourette's syndrome, ADHD, and reading disabilities. Dr Barr's team has identified genes that may contribute to these disorders. They're now focusing on understanding how those changes in DNA could influence genes and contribute to risk.

[music continues] Dr Maureen Lovett is a Senior Scientist Emeritus in Neurosciences and Mental Health at the Hospital for Sick Children. She founded and directed the hospital's Learning Disabilities Research Program for more than 35 years, developing and evaluating evidence-based interventions for children and youth who struggle to learn to read. Since 2020, Dr Lovett has served as Associate Director of the Haskins Global Literacy Hub at Yale University and the University of Connecticut.

Welcome. Thank you both so much for being here today. [music fades out]

Dr Cathy Barr 13:37
Thank you for having us.

Dr Maureen Lovett 13:38
Thank you, Heather. It's lovely to meet you.

Heather 13:42
It's lovely to meet you both too, and I know the two of you have worked together for a really long time—over 25 years—although you come from slightly different perspectives. So, how would you characterize your collaboration and your quest to solve reading disabilities?

Dr Cathy Barr 13:56
[laughing] Where do we start? It has been so many years.

Dr Maureen Lovett14:10
Well, I was the fortunate one because my background is that I did research and have been doing research for decades, trying to develop interventions that would accelerate the learning and the opportunities for children and teenagers with reading disabilities to get on the road to literacy and to be independent readers. And Cathy, in her wonderful genetics work, wanted someone on her students' thesis committees and on her grants, who had some clinical experience with this, so I was very fortunate to be approached by Cathy and have learned an enormous amount from her work.

Dr Cathy Barr 14:48
For me, I was really fortunate to be at Sick Kids with Maureen, who is really the expert in teaching and developing programs for kids to read. When you say Maureen's name at any scientific conference or any family conference, they're all like, "Oh, Maureen... I use the Empower Program." They can't say enough

because she's such a world leader and also, you know, working with Maureen, she guided us through the whole thing on what tests to give the children, how should we do the assessment, because when we do these for the assessment of the kids, we want to measure as much task and learning and reading and working memory as we can to get to the heart of what's happening. So, you know, developing the whole protocol that we use to see the kids was a big collaboration that took a long time, with myself and moving and other people on the team to make that happen.

Heather 15:36
Yeah, it really does take a village in this field, doesn't it?

Dr Cathy Barr 15:39
Mm-hmm, it does.

Heather 15:40
Okay, so let's go back to the basics for a moment and just really talk about reading disabilities 101. Dr Lovett, can you tell us how do you spot a reading disability?

Dr Maureen Lovett 15:47
Well, there's no mystery to it. Reading disabilities can be identified when a child's really having an inordinate amount of difficulty learning to read and learning the building blocks of reading, which are letters and the sounds and sound patterns that go with them. Reading really builds upon speech and language development, so the groundwork for it is laid before a child enters kindergarten or grade one and is introduced to reading instruction.

Often—too often—children aren't identified for help with reading struggles until they're in grades two or three, but in our group and in our program at Sick Kids, we've done research comparing the outcomes of going in and giving intervention—reading intervention, special teaching—every day, for an hour a day, through grade one, versus waiting to grade two, versus waiting to grade three, and the children who get the intervention earlier are the big winners. They gain more, they gain faster, and even after the intervention ends, they have a steeper trajectory in the years that follow.

So, I can't say enough about how important early intervention is, and that's not to say you can't go in and help a high-school kid who somehow got to high school and still lacks some of those foundational skills. We've demonstrated that also, that you can still work with adolescents and with adults, as well, and help them acquire foundational reading skills. But there are many reasons why a child may struggle to learn to read, and all of those kids don't necessarily have learning disabilities. Some of them may come from environments where books haven't been read at home and literacy isn't a high priority. They may be new to the English language. There are many, many reasons.

[gentle electronic music] Probably the most important conclusion to draw is that schools need to do screening of all the kids in kindergarten at the beginning, maybe at the middle, at the end, in grade one, and identify as early as you can, the kids who have signs that they're going to struggle, who aren't picking up on it, and then get those kids the help they need early because that's where the greatest benefit will occur.

Dr Cathy Barr 18:57
I want to also just add on to that because reading disability, it runs in families. They've known, even from the first description, that it was familial and then twin studies showed us it's genetic. But, because

it runs in families, quite often, one or both parents have difficulties reading, and because they have difficulty reading, often they don't have a lot of reading material in the home. They don't prioritize reading because it's difficult for them. It's not fun for them. So then, you get in the situation, you have a child with a reading disability, but also not a rich learning environment for reading. So, this is just complicated genetics, an environmental thing that can happen, which the one thing parents could be aware of is, "Okay, I need to really get the reading material in my home. I need to read to my child," and that can really help them.

Heather 19:43
Right. There's so many factors involved. We're going to talk about all of that today. I wanted to ask you, though, how big is the problem of reading disabilities, both for the person who's experiencing it, but also for society? Dr Lovett?

Dr Maureen Lovett 19:55
It's a huge problem because it's probably the most common learning disability that you find in schools or in the population. It's likely that there'll be one or two children in every classroom who has reading disabilities. It brings a real cost if intervention doesn't occur early. It has huge consequences in terms of anxiety and mental health, motivation, self-image. But, for society, it's been estimated that billions are lost in terms of lost productivity.

Heather 20:37
Billions?

Dr Maureen Lovett 20:38
Well, around the world, people have looked at the literacy and the health levels of families around the world and found that, in countries with higher levels of literacy amongst its population, you have higher standards of family health, of maternal health, and of the children's health. So, it's really a health problem and a public health problem.

Heather 21:16
It's fascinating. I hadn't heard that perspective before. Dr Barr, you look into the genetics behind reading disabilities and other neurodevelopmental disorders. Tell us a little bit about your work in this area.

Dr Cathy Barr 21:24
I entered into genetics a very long time ago—we don't want to say the years [Heather chuckles]—because I thought that, if we get into the genetics, we could really understand that biology and, if you really understand the biology, you can increase self-esteem. People who understand that, "I was born this way. I'm not stupid. I have difficulties reading because it's genetic." And so, if we understand biology, then people can say, "Oh yeah, I get that," and also, we can think about better interventions if we understand the brain regions that are involved, the cells that are involved, the genes that are involved, and I thought—and as did all geneticists—"If we get to the basis of the genes, we can start understanding it."

[gentle electronic music] Little did I know how many decades it would take for us to get to that spot to find those genes, because it turns out, with all these complex neurodevelopment disorders, they're just so much more complex than we thought. There's hundreds of genes coming together to create that risk, so finding those has been a major challenge. But now, that's finally happening, but it's taking worldwide effort. There are all the people in the world working on language and reading, who are putting all the

data from our samples together so that we can understand and get the power to find those genes, and it's taken that worldwide effort, and those are still ongoing, and the genes are still coming out.

Heather 22:38
So, you're identifying the genes, but you're also looking at how they interact with each other and the pathways. Just tell us a little bit more about that, and your work, in the context of really trying to understand the causes of reading disabilities.

Dr Cathy Barr 22:50
[bubbly electronic music] Mm-hmm. So, I think the most exciting thing that we found, just in the past few years, is there's always been this idea, based on quite old data, that there were changes in the migration of the cells during the brain development, during the fetal brain development. They saw these migration errors and they like, they're tiny. They're not something big. They're just tiny little clumps of cells that suggest the cells didn't end up in the right place. You know, this has always been this idea. Some of the genes coming out from the genetic studies are migration genes, so it's like, "Okay, this is kind of pointing us that this could be right."

But then, the stuff that's really fascinating is we started testing that in something called stem cell models. So now, one of the huge breakthroughs in biology and, you know, they won the Nobel prize for this, is they could take cells and reprogram back to a stem cell. And the stem cell is a type of cell that can become any other type of cell if you put it in the right conditions.

So, in our case, we took blood samples from the families where they are families that are participating in our studies and have consented to do these types of studies. We took two kids with very severe reading disabilities and their two very strong reader siblings, and we turned those cells into stem cells and then we turned them into neural cells, so we could try to mimic or model what's happening in the brain. And what we found was the cells from the kids with reading disability migrated much faster – like, dramatically faster. The people who had done these studies had never seen such fast migration. So, this was so amazing. I'm so amazed by that. [music fades out]

But then, we had to ask the next question – how does that have anything to do with the brain?

Heather 24:32
Yeah. what does that mean?

Dr Cathy Barr 24:33
Yeah. What does that mean? Because, in the dish, there's something that's happening in the dish, but how does that relate to the brain? And we know that, like using neuroimaging studies, the brains of kids with reading disabilities look pretty good. There's not huge traumatic migration errors. It's like something happened. It looks big in the dish, but it's maybe something in the brain. Maybe they migrate too fast and they kind of overshoot their connections, and so they're a little bit out of place and, when they don't make their connections, they're not going to make the connections between the neurons that are excitatory and the ones that are inhibitory. And this idea that there's an imbalance between those two types of cells is also a hypothesis that's been looked at for reading disabilities.

So, the next step was, "Okay, let's do a bigger study. We're going to do more of these stem cell studies, but we're going to do it in kids who are going to have neural imaging on their brain. So, we're actually going to see what we can compare, like, in the live person's brain. We're gonna look at their structure,

their neurochemistry, and their connectivity," and we've started this. We've got funding and we're working on it. And we're going to also take cells from the same kids and see how that compares to the dish, so we can try to put it together in a model.

And we can do all sorts of cool things. We can treat the cells with different kinds of compounds to see if we can get them back to their sibling. We can see if we can change the gene expression. We've also been looking in the cells we already have at Gene Expression, and we found 44 genes that are different between the kids who have reading disability and their siblings.

Heather 26:09
44.

Dr Cathy Barr 26:12
And then there's difference, and that's across two different cell types. And some cell types, there's more genes, but one of them is super interesting. It's a gene called OTX2, and it's interesting because what it does is it sets these time periods in the brain that are called "sensitive periods" and these sensitive periods are times in the brain development where it's more sensitive to external stimuli. So, there's part time periods where the eyes are more sensitive to input, when their ears are more sensitive to input, and if you block those periods, the development doesn't progress. And there's some support that there's also developmental periods for language. If you block language in certain time periods, it's harder to correct.

So, this gene, if it is involved in these sensitive periods, possibly for reading, we might have something very interesting to work with. And now, what we're doing is we're manipulating that gene to overexpress it, to see what happens in the cells, and can we tie the risk genes into this network, and we have that data on the sequencer and we're just waiting for it to come out – anxiously waiting for it to come out.

Heather 27:19
Oh, anxiously, I'm sure. You're using CRISPR, right?

Dr Cathy Barr 27:22
So, CRISPR is another huge breakthrough that happened, and it's being used for all sorts of applications. And the people who did it also won a Nobel Prize. It's been a breakthrough. We use it in the dish. What we can do with it is you can specifically activate one single gene or deactivate one single gene by targeting these enzymes that have been modified to one specific location. So, in our case, what we're doing is we take the enzymes that activate—they've been modified so they activate—and they go right to the gene and they turn it on. So, we can overexpress it, trying to mimic what happened in the kids with reading disability cells, and see overexpression of this gene. So, using these technologies, we can turn it up, turn it down, and then discover what happens.

Heather 28:13
Right. See what kind of impact it can have.

Dr Cathy Barr 28:16
Yeah, we can look at the cells, see how they change. Do they migrate differently when we do this? Trying to put it all into one network.

Heather 28:22
Trying to find the answer, finally.

Dr Cathy Barr 28:25
[chuckling lightly] Trying to find that answer. [Heather chuckles]

Heather 28:27
Dr Lovett, I'd love to hear your reaction to all of these exciting advances going on in research right now.

Dr Maureen Lovett 28:32
I'm extremely excited to hear these latest developments because Cathy and I haven't caught up in a while on the research side. I think it's absolutely fascinating and wonderful that it can be done, and that it's being done here. I'm always fascinated by issues of how the genetics affect brain development. So, we know from some work from developmental neuroscientist, Nadine Gaab, that if you look at kids at risk for reading disability from these family associations that Cathy references, that if you do neural imaging, that the kids at risk of developing it show slightly different trajectories of brain development before they come to school, when they're just little ones. So, to be able to go back to gene and then to try to understand how these brain pathways are laid down and develop and may develop differently in children who are more at risk with these developmental learning disorders, is absolutely fascinating.

Heather 29:59
And so, that couples with the interventions that you've been so involved in your entire career, Dr Lovett. What are we understanding about, you know, how much of reading disabilities could be genetic in terms of the links that you're discovering, Dr Barr? And, how much could be environmental in terms of someone's circumstances and, you know, some of their family situation, their schooling, everything else that impacts somebody's education and ability to read?

Dr Maureen Lovett 30:23
All of these things interact, of course. Whether your difficulties come from your environmental circumstances, from different language backgrounds, from socioeconomic differences that may have exposed you to less language and a smaller vocabulary when you're growing up, the solution is really the same. They all require early, intensive literacy intervention –[upbeat electronic music] teaching the kids the building blocks of printed language, starting with letters and sounds and letter patterns and sounds, becoming more complex, and teaching strategies for how you decode words you've never seen before, how you use what you know together what you don't know.

So, our particular interventions, we like to always see kids in groups, not one-on-one. Some people believe that the most-intense interventions have to be given one-on-one with a tutor or a teacher, but actually, we like to capitalize upon the social aspects of the small group, and certainly, for kids who are struggling to learn to read, it's very validating and supportive to be with other kids who are going through the same situation, and it normalizes it, and the kids can grow together in response to the instruction.

And that is particularly powerful when you get to middle school or high school, when the kids are in adolescence and they're carrying a lot of baggage from their struggles with reading over the grades. [music fades out]

Heather 32:23

Dr Barr, I know some of your work relates back to other conditions that you're discovering now might have a link to reading disabilities – other neurodevelopmental conditions. Can you speak to that?

Dr Cathy Barr 32:34
Sure. Yeah. So, for decades, we've known there's a relationship to attention deficit hyperactivity disorder. We've known that from, like, the high prevalence of ADHD and kids with reading disability. But then, in the '90s, people out of Colorado studied twins so that there is actually genetic relationship, and it's more for the inattention symptoms compared to the hyperactive impulse. But now, these large genetic studies we're doing, you can actually look at these overlaps, and so now, we can see exactly what they saw in the twin studies. There is a strong relationship with ADHD.

But the most recent study is also showing a relationship with depression, which is incredibly interesting because we know that kids often have high rates of depression. Mostly, that's because of their, you know, lack of self-esteem, but there's a genetic relationship. We also see a relation between educational attainment, genetically, but of course, if you're a poor reader, you're not going to achieve the same level of education, so that's an easy one. It's like, "Okay, that makes sense."

One that we didn't anticipate, and should have, is that we're seeing—not in all studies, but in our study—a relationship to autism, and that maybe should have been surprising because they're both language-based neurodevelopmental disorders. So, it's possible—we do see a lot of shared genes across neurodevelopment disorders because the genes are important for brain development, so therefore they contribute to a lot of different things—but this was a little surprising, and maybe it just related to our sample because our sample, we've previously seen, as a group, that kids with reading disability are more language delayed than their strong reader sibling. So, maybe it's the way we've selected this sample to be very impaired and they're maybe just more likely to have had this language delay.

Heather 34:25
Interesting finding, regardless.

Dr Cathy Barr 34:27
We're trying to figure out, you know, how are those genes related. How do they end up with a different outcome?

Heather 34:32
Well, somebody might be listening today and they might be thinking, "You know, okay, if there's a genetic link to reading disabilities, then you know what control could I possibly have over, you know, my destiny, my future?" So, what would you say to them?

Dr Cathy Barr 34:46
What we know is that we can say, as a population, it has a genetic component. It also has an environmental component and we know one of the strongest predictors is early print exposure, being read to. So, you can't control your genetics. You got what you got. But you can control the environmental part. You can control how much reading and special intervention you get. This is what you can do, and it's the same for everybody. Everybody's reading can be improved.

Dr Maureen Lovett 35:12
I guess I would just like to also add, for those parents, it's just because we're talking about the genes and the brain, neurobiology isn't destiny. Our brain circuitry is changing as we learn and as we experience

different things and, in the area of intervention and special teaching programs for these children, people have done research where there has been neuroimaging of the child's brain, doing reading-related tasks before an intervention, during an intervention, and then after they're finished, and they observe a variety of changes in the circuitry in the brain that's imaged with successful intervention.

So, with learning to read, successful reading development results in a circuitry, a brain circuitry, that builds upon the circuits that develop in our brain for speech and language, and there's evidence to show that the more skilled the reader, the more tightly intertwined in the brain that circuitry is. It builds on top of the speech and language circuitry. And, certainly, there are changes with intervention that you can see on FMRI imaging. Now, some people have talked about that as a normalizing, that atypical circuitry is being normalized to what you see in readers who acquire literacy without struggles; others have said it's a combination of normalizing and compensatory changes – ways to compensate for what has been so difficult. So, it's not destiny.

Heather 37:20
Mm-hmm. That's good. I mean, it all comes down to neuroplasticity and the amazing ability of the brain to rewire itself. Dr Lovett, you had mentioned to me, in our prior conversations, about the feedback that you've gotten over the years from parents, and even from students that you worked with many years ago, who have come back to tell you about their lives and about their, you know, newfound career. So, tell me a little bit about that and how rewarding it is to hear that kind of feedback.

Dr Maureen Lovett 37:46
[uplifting electronic music] Well, our research program has now evolved into the Empower Reading and Learning Group at Sick Kids, and has rolled out to five provinces and one territory in Canada, and to some states in the United States. So, the programs we developed in research are being taught in schools over a very broad area, and some teachers and some parents have been very kind and thoughtful and have written letters and emails to us, saying that, "Having my child in this intervention has changed our life as a family," that the whole family had felt the struggle and, as the child became a reader and experienced success, that that tension and that stress was relieved and replaced with a good feeling within the child and within the family. And you know, Heather, I cannot tell you how much these letters and messages mean to us. It really means the world.

Heather 39:02
Isn't that what this is all about, ultimately?

Dr Maureen Lovett 39:04
It is. [music fades out]

Heather 39:05
Dr Barr, do you have any final words or sort of a bottom-line message that you're hoping people will take away from everything that they've learned today?

Dr Cathy Barr 39:13
I think the most important thing is what Maureen said is, if your child is struggling, you're struggling, you can get help, you can become a better reader. Recently, that Ontario Human Rights Commission actually did an investigation and determined that reading is a basic human right. Same thing had already happened at the Canada level. Not being able to read in this society can really affect your livelihood,

your ability to provide for your family, your thoughts about yourself, your mood. It's really important to get help at however level you can get it, and I guess that's my takeaway.

Heather 39:47
[gentle, upbeat electronic music] And ultimately, this podcast is about connecting the public with the research that's going on, so I'm really happy that we've had that opportunity today to learn more about your work, Dr Barr, and more about your amazing career, Dr Lovett. Thank you both so much for being here today.

Dr Cathy Barr 40:01
Thank you, Heather.

Dr Maureen Lovett 40:01
Thank you so much for having us, Heather. It's been a pleasure.

Heather 40:12
[Your Complex Brain theme music] Thanks so much to Dr Cathy Barr and to Dr Maureen Lovett for joining me on the podcast today. A big thank you, as well, to Matthew Côté for sharing his inspirational story with us. If you'd like to learn more about Matthew's personal journey and his path to becoming a teacher, head to our website–uhn.ca/krembil–and click on the show notes for today's episode.

[music continues] This episode of Your Complex Brain was produced by Jessica Schmidt. Dr. Amy Ma is our executive producer. Thanks also to Kim Perry, Meagan Anderi, Sara Yuan, Liz Chapman, and Lorna Gilfedder for their production assistance.

[music continues] If you enjoyed this episode of Your Complex Brain, please tell your family and friends, and don't forget to leave a rating and review on your favourite podcast listening app. We'll be back in two weeks with another exciting episode. Have a great day. [music continues then ends]