Season Intro and Genetics Overview

Hello. Welcome to season five of the baby manual podcast. This season I'm interviewing pediatric subspecialists so that they can tell you all about the special things that do in their fields.

Reasons that you might get referred to a sub specialist and also things you can try at home before your specialist visit. Today I have the pleasure of talking with Dr.

David Tigay, who's a DO and he's one of most brilliant people I've ever met. He talks all of genetic testing, and why different families choose to get genetic testing and the sorts of things they can find, and also how the testing is done.

So I hope you enjoy it. Hello, welcome to this week's episode of the Baby Manual Podcast. Today, I have the pleasure of talking with Dr. David Tigay, who's a DO and a geneticist.

Dr Tigaye, tell me a little bit about yourself and how you got into genetics and where you work, that kind of thing. Absolutely. Thanks so much, Carol.

found out about genetics while I was actually in residency. It still isn't the most common path for doctors to take. And in fact, not one that's talked about nearly as much as it should be during medical school.

So when I got to residency, there was a really interesting case, a patient who had a not so rare genetic condition, but had some really unusual findings that didn't go along with that diagnosis.

Everyone was really perplexed as to what was going on. Why would they would have these other things that you normally wouldn't see with this already unusual genetic syndrome.

Dr. Tigay's Path Into Genetics

So they called in a clinical geneticist, which I didn't know existed at the time. It was a relatively small community hospital. Geneticists are much more common at large tertiary care medical centers.

She came over from Mount Sinai to do a consult on this patient and immediately was able to discern exactly what genetic syndromes were present just from physical exam, and then we were able to confirm that on genetic testing.

And so for me, that was just fascinating. It was like a little bit like playing house MD with genetics. So I was hooked. I wasn't an internal medicine residency at the time, which is not the most common pathway into genetics, it's most often from pediatrics because most you know, genetic conditions are often identified during the pediatric period.

But they said, look, we would really love to have you do a fellowship in genetics. And the fellowship is age agnostic. It's a geneticist, clinical geneticists can see patients of all ages from birth and even prenatally all the way through adulthood.

So I completed my fellowship over at Mount Sinai and then the rest is history. That's really cool. And I think we all know that, you know, genes live on chromosomes and there's different types of genetic testing.

Can you talk a little bit about like, what does a genetic test look like to a patient? I assume, is it a blood test? Is it, a cheek swab? You know what, where do you get samples from and what kind of things does that tell us?

Oftentimes when, when patients hear the word genetic, testing, it creates some, some anxiety and some uncertainty about what is going to be involved. In truth, most genetic tests are no different than any other routine

laboratory testing that you're going to do in terms of how we obtain the sample.

Historically, we would obtain a blood sample to perform genetic testing. But now, it's much more commonplace even to obtain an example on a cheek swab or a saliva sample, so non-invasively.

The thing about genetic test that makes it different from, let's say, a routine test like Checking your your blood counts to see if you have anemia which is either like a yes or no you either have any mirror your don't.

Or pregnancy test you're either pregnant or you not right with a genetic test what they do is they read in many cases the chemical letters of the DNA sequence or they look for variations in.

The formation of a copy number as we call it of chromosomes and when they find a change. they have to interpret whether it's significant or not. And many times they can do that and give you, yes, we found an answer for whatever we were looking for on the test.

How Genetic Testing Works

Or sometimes, no, didn't find any problems, which doesn't give us an answers, but at least tells us it is not a problem with whatever were testing for.

But many time when they find a change on a genetic test, the lab is unable to confidently tell us whether that change would result in issues or and we call that an uncertain variant.

So there's a lot of counseling that has to go into genetic testing because we have to explain to people that when the result comes back, it could be a yes or a no, but sometimes it's little bit in between and there may be other things we need to do to resolve that uncertainty if we can.

And then of course, because were looking for genetic changes, there can be implications for other family members in some cases when they're heritable, which they not always are, sometimes they could.

That's really neat. The gene might be there, be doing something or it might be something in a different way than you'd expect. That's really cool. So how does that come into play with like prenatal genetic testing?

Because I know You know, back in the day, we used to only do levels of different hormones in mom's blood. And now we have this non-invasive prenatal testing where they take a blood sample from mom while she's pregnant.

They look for cells that actually belong to the baby, and then they test the genes that are on those cells. Are those fairly accurate? Is that also still kind of a gray area where we say like, it looks like something's there, but maybe the gene isn't going to get turned on.

Yeah. Prenatial testing has, has come a long way. Some of the, biggest advancements have occurred in the prenatal space in terms of testing that's available.

A lot of it arose out of the desire, try and determine during or even before a pregnancy, whether there could be risk to a fetus of having a genetic condition or a birth defect.

And so the kind of original screen that we did was just based on something simple like maternal age, just knowing that the incidence of certain chromosomal abnormalities increases to some degree with maternal age.

That was used as a basis for doing further testing in those parents, but that screening was not very sensitive. It didn't detect many cases of fetuses that would be affected by chromosomal anomalies or birth defects, certainly.

When it was discovered that you could look at the levels of certain analytes, proteins within maternal blood during a pregnancy and that could give you an adjusted risk of how likely that that you just might have a condition like let's say down syndrome or another chromosomal trisomy or even certain birth defects with the case of maternal serum

AFP levels for open neural tube defects.

They started to incorporate that into sort of routine prenatal care and, and the, uh, the gold standard for a long time was the second trimester that, you know, triple screen, right?

And then. as more analytes were discovered, that was added onto, they had a quad screen, and then they were able to do it earlier, looking at some analyts that may go up or down earlier in pregnancy, like pregnancy-associated plasma protein A and nuchal thickness and ultrasound.

But for all of those tests, um, there were not diagnostic. They were screening tests. So there was a percent of people who might have a suggestive pattern of increased risk, but yet might not have fetus that's affected by one of these conditions.

And the way to Determine that sometimes it could be fleshed out by doing, let's say, imaging studies in the case of certain birth defects. But in a case with things like trisomy 21 or other chromosomal syndromes, quite often you have to do an invasive procedure.

an amniocentesis or a CVS to actually determine whether that increased risk was real or not.

Prenatal Screening and Diagnostic Testing

So amneocentesis is where they put a big needle into the abdomen and suck out some of the amyotic fluid or chorionic Felix sampling CVs, where, they would take some, of, the placental cells and then test those.

And those, because you're putting a, big, needle in the, abdomen, and they had a risk of causing a miscarriage. and so that's why those were not standard of care, but, but can give you an accurate test of like getting the fetal cells out, right?

Yeah, you could actually test the cells from the, from, the from fetus. Um, so it was much more accurate, much, more diagnostic, but came with risk. And so because of that, there was a great desire to find better, uh, sensitive, and more specific tests.

There was discovery that during pregnancy, some of the DNA from cells of fetuses, primarily from placenta will enter into the maternal circulation. Um, and usually in the form of what we call cell free fetal DNA.

So it's actually the raw DNA that came out of cells that let's say had lice and, um, it goes into the mom's blood. It crosses the placenta and ends up in mom circulation.

Um. As opposed to going and invasively taking cells from the baby, you can actually interrogate the DNA from that fetus in a mom. Blood during the pregnancy, It's not something.

And so as the pregnant goes on, the levels do go up. You know, once you get to around. Um, 10 weeks, you have pretty good fetal fraction of DNA in the maternal circulation.

And you can look for things like aneuploidies like, like trisomy 21, which causes Down syndrome. You can even, uh, look what we call monogenic disorder.

So see if someone has a mutation in a specific sequence of, of. That's usually only done if there's a reason to think that the fetus is at risk for having one of those conditions, let's say a family history of muscular dystrophy or fragile X syndrome, But for all pregnancies now, it's recommended that we offer what we call non-invasive prenatal testing, which looks at the cell-free fetal DNA for adjusting the risk of there being an aneuploidy like Trisomy 21 or Down syndrome and some other conditions as well.

It's a much more, not invasive, just done on a blood sample. Much more sensitive than the prior methods. So some of the things like the triple screen or the quad screen, or first trimester screening, would detect like 70 to 85% of

cases of fetuses that might be affected with one of these conditions.

But with the non-invasive prenatal testing, you're getting upwards of 99% sensitivity detection rates with much fewer false positives. So much less need for invasive procedures in individuals who don't have a fetus that's affected by this.

That's amazing. And also it sounds like you can do it. in the first trimester rather than having to wait all the way till the second trimesters. So it's a lot earlier on that you would know these things.

That's so cool. Can those tests still be done on people that have twins or triplets? So they can. They can be on twins. For many of the conditions, things are pretty well validated.

It is almost as sensitive and specific. There may be a slight drop off with increasing numbers of gestations then. that can start to be affected a little bit.

But there are studies that show that it's still accurate in twins. So suppose something comes up positive on this prenatal testing for a parent, some genetic condition.

Is that definitely there? Do they need a screening test later to see if it is actually that? So again, even this non-invasive cell-free fetal DNA is a screen only.

There are reasons why there could be false negatives or false positives, albeit rare. but certainly we often want to do other things to sort of confirm or validate that the result that we're seeing is real.

And so, for example, if the test comes back that there's an increased risk for something like trisomy 21, which causes Down syndrome, usually there will be other markers that you can look for, let's say an ultrasound evaluation.

If you want do some non-invasive testing, you could look those markers and see whether they're present or not. that makes you more confident in the result.

If they're not present, it still could be that, but it makes it a little less likely. Ultimately, the only way to know for sure is still to do an invasive test, like an AMNEO or a CVS.

So those might still be suggested. They might be still suggested, But if there's enough other evidence from non-invasive testing like ultrasounds, then many individuals would not choose to go forward with that test.

I will say that there can be reasons for, you know, for false positives. For example, sometimes a parent may actually have a low level of what we call mosaicism, where a couple of their cells may have the aneuploidy, and that may be making it look like there's an increased number of copies of that chromosome.

Also, there could be a reason for what's called false negatives. So, they're endy people who have this screen and yet still have fetus that might be affected by this.

And that could sometimes be because genetic change may be confined to the fetus and less present within the placenta. And so most of the cell free field DNA is coming from the Placenta, and so the foetus may have a slightly different genotype.

So if you still see those ultrasound anomalies, you may still want to go forward with an invasive test, even though the noninvasive prenatal testing was not suggesting increased risk.

Conversely, if the Noninvasive Prenatal Test is positive, there can be reasons for false positives there as well. What are some common genetic things that are present, like in newborns and that we might notice in the newborn nursery?

Yeah, so I think one of the main reasons why we're all often called to consult are the presence of a birth defect, a congenital anomaly. Many times those are known about during the pregnancy because they're seen on an ultrasound or suggested by one those non-invasive screening tests.

but those are not perfect methodologies. And so sometimes babies are born and they may have a birth defect about three to 5% actually of all. pregnancies have some sort of congenital anomaly.

Sounds like a lot, sounds scary, but the converse is that 95 to 97 percent of the time there's not a congener anomaly, right? Yeah, and some of those anomalies that you see at birth aren't necessarily significant, like they're not going to need further workup or surgery or things like that.

It's just something that happens to be there, or is it? Yeah, no, that is true. They're not necessarily always a functional consequence or a pathologic consequence to every congenital anomaly that might be present, right?

For example, there's an anomaly we call syndactyly where there is a small bit of connective tissue bridging between the digits. Sometimes it's minor, it doesn't really affect anything, but there may be, you know, web toes as they call them, But there are no functional significance.

But whenever you see that, whenever see an Anomaly, even if it has no pathological significance, It just means you have to, your radar has to go up that you take a good look and make sure that there's nothing else going on.

That there are not other anomalies that are present that had been missed. And also you to look for those other cardinal signs of genetic conditions. Some of the signs that we often see are abnormalities in growth.

Newborn Findings and When to Refer

So was this a baby that has unexplained intrauterine growth restriction, or was unusually large without an explanation? Are there abnormality of neurologic tone?

Is this baby abnormally hypotonic or low tone or hypertonic or increased tone? And then are there what we call dysmorphic features? So mild variations in the physical findings that could suggest the possibility of a genetic syndrome.

If you're seeing those things together with a birth defect, it increases the chance significantly that there could be an underlying genetic condition that might have other implications later on and where genetic workup is going to be important.

When you mentioned tone, what that means is the strength of the baby, how strong their muscles are. So if the babies more like floppy than normal, that would be low tone or if they're more stiff, there would a higher increased tone in babies.

Yeah, so there are some subtle things that we look for in the hospital to see like, is there something else going on? Like you said, sometimes they can be missed, but I know when I notice like three or more things in same baby is usually when will put in a consult for genetics, I mean, I would certainly say that if you're seeing multiple issues, then it's never wrong to have a genetic consultation just to look into a little bit further.

Some things are really common, so dysmorphic features are very common. In fact, it is normal to a couple physical features that are slightly outside the normal range.

So that alone, just having one or two slightly abnormal facial features or physical feature doesn't necessarily necessitate a generic consultation. But when you see those in combination with the other things, then it becomes important.

Even certain birth defects on their own are known to have a high incidence of underlying genetic causes. And so even if you have congenital heart defect, let's say, there's some common ones.

Let's take a bicuspidia or a valve, which is congential, but doesn't tend to cause issues till later in life. If you find that, that usually is not going to prompt a genetic evaluation because it's a pretty common finding.

It's pretty unusual that we would find an underlying genetic cause for it or syndrome associated with it. Uh, but if it's a more complex congenital heart defect, like a tetralogy of follow, or let's say a large septal defect.

We do know that there's an increased incidence of underlying, genetic changes that can cause that, uh, where there can be other implications. And so it is important to look for those reasons to help provide, you know, proactive care to the child.

And also to figure out whether there are recurrence risks for that child when they get older and have kids or for the family and future pregnancies. Yeah.

And I remember that heart defects are one of the more common. things that we, you know, malformations that happen in babies. And so we screen for those both by listening to baby's heart in the nursery, but also by doing what we call the CCHD or critical congenital heart disease screening, which is where we put a pulse oximeter, a light just on baby hand and foot and see if there's a difference in oxygen that's going from one to the other.

Would you say most things are caught with those two screens while the baby is still in hospital or do these sometimes show up later in life? I would say that a large percent certainly are caught, and especially the ones that are likely to have early functional significance.

Yeah. The more dangerous ones. Exactly. There are many more… So congenital heart defects actually occur in almost 1% of all live births. It's 0.8% technically.

So it is probably actually the most common type of birth defect that we consider. Some of them have significant functional consequences, most of those are picked up with the newborn screening that you mentioned or through physical exam.

But there can be, again, more mild anomalies where there may not be a distinctive audible murmur that might hear and there might not a problem with pulse ox and therefore it might go undiagnosed.

So it certainly is detecting a lot of the critically important ones. So for some children who are later in life to need genetic testing, I know that sometimes when children have autism, we do genetic tests to look to see if there's anything else going on.

Is that universal in all children on the autism spectrum? Or are there certain other things that, say, a general pediatrician might look for before making this referral to genetics?

Are there other reasons that older children would get referred to a geneticist, something that wouldn't be present in the newborn period? Yeah, I would say that there's an increasing awareness that many conditions that have been until relatively recently unexplained in some cases or even in a majority of cases have a genetic origin and that we are using new genetic technologies much more often able to detect, which can be important again in providing the necessary medical care to optimize their development later in life.

developmental disabilities, including autism amongst them, are a group of conditions where quite often there is a specific genetic reason that can be uncovered, increasingly so with newer genetic testing.

And so things like what we call whole exome sequencing or whole genome sequencing, where we're not looking just at the DNA sequence of a specifically gene for a particular syndrome, but rather looking at thousands of genes all at once.

are able to uncover a cause for things like autism in upwards of about 50 to 60% cases now. In the remainder of cases, there may still be genetic reasons that just were not able be identified using those methodologies.

And there are maybe some other tests that we can do to increase that fraction a bit. That is really an essential thing because it just, A, can relieve some parental burden of anxiety that they may have done something, let's say, during or before the pregnancy that caused the child to have those aberrant behavioral developmental patterns.

But it also can be important in terms of finding potentially treatable conditions that sometimes arise for genetic testing. And also in a better informing families about the chance of recurrence in future pregnancies as well.

Autism, Developmental Disorders, and Exome Sequencing

So lots of reasons to do it. Um, but a condition like autism is something that yet you're not going to see any obvious symptoms right at birth. features become more noticeable and so the current recommendations are that everyone anyone with unexplained regardless of age whether they're child adolescent or adult with an explained intellectual disability developmental disability autism spectrum disorders.

should have certain genetic tests. And first line amongst them is actually the whole exome sequencing. Just going back to the newborn stuff, I forgot to ask about the new born screen, which I know are you mentioned treatable genetic diseases.

So we do this newborn screen in babies before they leave the hospital. We're looking for a bunch of things because they can be treated. If they are treated, they could have lifelong And if they're not treated to lifelong consequences, can you just lightly touch on that for parents?

What the newborn screen looks like, how it's done, and what sort of information we gained from that? Absolutely. So yeah, newborn screening is an invaluable tool for, as you mentioned, detecting a number of different conditions, mostly genetic, but even some non-genetic conditions where if we waited for symptoms to occur to allow us to make the diagnosis and then started treating after that point, we would end up with significantly worse outcomes.

And so by screening before symptoms occur, by screen right at birth, We can detect those conditions earlier and we can ideally start treatments before those symptoms have irreversible consequences.

And that's been shown to be the case for a number of different genetic conditions. And in fact, that list is ever expanding because as we develop new therapies for previously untreatable conditions, and when we discover that initiating those therapies earlier or before you would have made a diagnosis after waiting for symptoms to occur, you can get better outcomes.

The need for expanding those panels even more becomes of critical importance. Yeah, that's awesome. And I know some of the treatments for those are as simple as they need to be on a special formula instead of breast milk or things like that.

I imagine some get more complicated than that? Absolutely, absolutely. Even for some those, we have other treatments that are a little more complicate but often more effective.

But the kind of prototypical case in point is something like phenylketonuria or PKU, right? Which is a disorder, an inborn genetic disorder of metabolism of a particular amino acid called When you can't metabolize it, it builds up and causes toxicity to the brain and also deficiencies of some downstream amino acids.

And so before we had newborn screening, these patients were only identified because they developed unexplained, pretty severe intellectual disability, a high instance of autism, and some other characteristic physical findings.

At that point, many of those were irreversible consequences. It was discovered that if you treated patients with PKU with a diet that was restricted in phenylalanine using, as you mentioned, metabolic formulas that have the other essential amino acids, but much reduced levels of phenyalanin, that you could control those phenalalanins levels.

And the earlier you started, the better the outcomes, right? And so that. Was the big impetus for having that added

into newborn screening so we could identify these babies.

Newborn Screening and Treatable Conditions

before that irreversible damage, institute that relatively simple initial restriction of phenylalanine in the diet and end up with near normal outcomes.

That's so cool. And you had mentioned just coming full circle now back to the beginning of the podcast, you mentioned that sometimes we even do testing before parents are pregnant.

What does that look for? What is that doing? How does it look like? Yeah, so there are a number of reasons why we might offer genetic testing to prospective parents even before pregnancy.

Most obvious probably is that there's, let's say, a known family history of a genetic condition. And if it looks like one where there could be risk of transmission, families may be offered testing, to see if they are carrier for one of those conditions.

But even if there is no family, history, many genetic conditions occur in what we call a recessive pattern where both parents may Need to be carriers, but they are usually unaffected.

So they might not know that it's in the family There are are increasingly robust screening panels for Mutation or as homo recessive mutations that people could be carries for we all carry Everyone carries a half dozen or so of these genetic changes in genes that are not affecting us But if our partner carries the change in same gene, we have a risk of both pass to get on to our offspring about 25% risk with each pregnancy.

And those are conditions that we're able to screen for before conception. So that if two parents know that they're at risk of having an affected child, they can avail themselves of all the different options to reduce the chance that the child might have that condition.

Sometimes that involves deciding on using a donor egg or donor sperm that's shown not to be a carrier. Other times that using something called pre-implantation genetic diagnosis, where eggs and sperm are harvested from the prospective parents who we know are carriers to make sure that they then test the embryos before implantation to ensure that the ones that you would implant would not be affected by the condition.

That's cool. So that's like IVF and testing the little embryo's before you put them back in. Wow. With pre-implantation genetic testing. Is this something that everyone should do before having a baby or is this like a, you know, what sort of parents should think about doing prenatal genetic So we recommend and we offer prenatal carrier screening and preconception carrier screen even before pregnancy.

That's the ideal time to do it. Because if you do before a pregnancy, you can use things like IVF and pre-implantation genetic testing as opposed to having to only face the decision of testing during the pregnancy and then whether to continue the pregnant knowing that information.

And so ideally you want to this carrier preconceptually before you get pregnant. Um, the current recommendations are that, that all individuals, regardless of ethnic background, there are certain genetic conditions that you see a little more often in certain ethnic backgrounds because of what we call founder mutations or other reasons.

But all the individuals regardless, I think background should be offered preconception carrier screening. And those panels have, as I mentioned, become much more robust.

In the past, There was only like two core disorders or four core.

Carrier Screening and Preconception Testing

Disorders now. these panels are able to screen for carrier status for hundreds of different conditions. Wow. That's

really cool. So it seems like the overarching message with genetics is the sooner you know, the better, right?

The better the outcomes. Right. It definitely gives you the opportunity to intervene and achieve better outcomes or even, in some cases, prevent passing on genetic traits that might cause these conditions Are there any common genetic conditions you can think of that would have the need for other specialists to be involved?

Like things that tend to have all these other, but yeah, and sort of touch on a couple of those. I know with trisomy 21, we always want to involve a cardiologist because they have a higher incidence than the normal population of heart defects.

Genetic conditions, some of them may present only affecting a single organ system with it. and may not necessarily need what we call multidisciplinary care.

But many genetic conditions, especially syndromes, are groups of things running together affecting multiple organ systems. And those patients benefit from multisciplinary.

In the case of something like Trisomy 21, where there can be effects on the neurologic system in terms of tone and cognitive development, whether it can effects in the heart in general heart defects, on gastrointestinal tract, In terms of various kinds of mobility issues or congenital anomalies on the endocrine system in terms hypothyroidism can see that we have to have a whole cadre of specialists that are involved in helping manage these patients to get best outcomes.

Awesome. So I imagine that's something that. say, I guess, latest case scenario would be picked up maybe in the newborn nursery or on this prenatal testing.

And then the doctor that's their general pediatrician or their obstetrician might even start making suggestions and recommendations for what type of specialists they might need to see.

Absolutely. So many times, and increasingly so, we're identifying it pre-natally, something like trisomy 21. Then your families will be counseled about the full spectrum of potential medical issues that could arise.

also what kind of care teams they will be connected to to help optimize outcomes. And if the condition is not found prenatally, then many times at birth the telltale signs of that condition will lead to a consultation with a geneticist to confirm the diagnosis or perhaps the neonatologist or pediatrician may send the genetic testing, the chromosome analysis and make the And at that point, then you would be looking for all the different things that you know can come along.

They don't always come alone, but can't come long with that diagnosis and making sure that the right specialists are brought into play. I don' know if we could just provide a little reassurance.

And I know I've had a lot of friends reach out to me because something was found on ultrasound that ended up not being significant. In the end, things like, I mean, like a two vessel cord, is that something that they need to worry about or a spot, a bright spot that shows up on the heart or a right spot on back of the neck.

Can you just say like, are those likely, if they just find one thing, I feel like a lot of times that doesn't mean a whole lot. Yeah. So there, there are a of, we call soft markers on ultrasound, which are, Which are subtle changes that may or may not by themselves cause any issues for the, the baby.

Multidisciplinary Care and Future of Genetics

But when you see them prenatally, they are risk factors for potentially having certain genetic conditions and the more that you see the, more likely that one of those conditions might be present.

And so you don't want to cause undue concern, uh, because there's a good chance if they find a particular thing that it may not, the baby may be affected by one those.

But you do want take a closer look and make sure that there aren't other ultrasound markers that your finding, or you may want go forward. with other genetic testing to look into it further if people want a higher degree of certainty about that.

There have been tremendous advances in our understanding of the genetic basis for a number of conditions that were previously unexplained. And so genetic, testing and evaluation is becoming much more commonplace and much important for host of different conditions, both pediatric conditions as well as adult onset conditions and some case in points are things like epilepsy, right?

So we now know that with unexplained epilepsy we can find a genetic etiology, again, in upwards of 50 to 60% of cases. And many times it's using that newer technology of whole exome or whole genome sequencing, which gives us, it looks like the higher yields and is making its way into the first line for evaluation of those conditions.

The reasons again are not just to provide a label, If you find the theology, there may be specific treatments that will work better for those patients and give you better outcomes.

And it's the same thing for epilepsy as it is for autism and, and even in some cases for adult onset conditions, like let's say Parkinson's disease, if there's a family history or an unusually early onset.

genetic testing is starting to become an increasingly recommended try and parse out the reasons and see whether there might be therapies or clinical trials that would be able to help patients with those specific genetic causes.

That's really amazing. I feel like genetics is probably the one field that has come the farthest in recent years that there's just been so many like updates back when I was in medical school, which was I don't know, like 20-ish years ago at this point.

A lot of the treatments for this were what they called genetic counseling, which was just like, maybe don' have any more kids right now. And until we figure out what's causing this, and now it's like there's actually individualized therapies.

There's things that target specific genes, whole genome sequencing. I remember in high school, learning about how they were mapping the human genome, and then it was done.

And now it's, I mean, we just know so much more than we did not even that long ago. So it is pretty incredible how far this has come and like how much optimistic I am about the field of genetics versus back, back in the day when we were like, like you said, it, was like playing house.

But then once you found the diagnosis, you were, this is, We can't do anything about it. Absolutely. It's a truly exciting time. to be in the genetics field.

And one of the most encouraging things is that we're moving from the phase of just being able to figure out, OK, this is the genetic cause of that condition to actually saying, how do we translate that into guided precision treatments that correctly underlying genetic etiology?

And so whether it's through RNA-based therapeutics or gene therapies or just targeted small molecules, every increasing number of conditions, we're able to offer treatments, not just counseling and reassurance, but actual interventions that can improve care.

That is so awesome. Well, thank you so much for being here today. It was a real absolute pleasure to talk to you. You're one of the smartest people I've ever met, and this was really enlightening.

I hope our listeners have also found it really interesting. Thank you for tuning in. Make sure that you like and subscribe so that can be the first to know when new episodes come out.

Also, you can check out the four first seasons of the Baby Manual podcast on your favorite podcasting platform, or

check my YouTube channel for lots of videos and shorts that will help you feel empowered as a new parent as I answer all of common questions that tend to come up in the couple of years of life.

Have a wonderful day.