Genetic Counseling: Undergrad Edition

Issue I

Introduction to Genetic Counseling

Fall 2018

Dear Reader,

Welcome to the first ever issue of Genetic Counseling: Undergrad Edition! Members of the Genetic Counseling Club at the University of Pittsburgh established this newsletter firstly as a resource for students who are interested in genetic counseling but are unable to attend meetings. However, we hope it will also serve as a guide to genetic counseling for everyone, even those with just a passing interest in the field. We hope to advise, inspire and, most of all, educate.

Our president, Daisy Ritenour, first brought this idea to the club at the beginning of the semester. Since then, we have worked hard to create this newsletter from the ground up and we hope it will continue long after we have graduated, standing as a monument to our passion and dedication for the field of genetic counseling. This first issue is meant to serve as a basic guide to the field, while the following issues will go more in depth on various topics. If you enjoyed reading or have thoughts on what we should explore in our next issue, please reach out to us at pittgeneticcounselingclub@gmail.com. Otherwise, look for our next publication near the end of the spring 2019 semester.

Bailey Sasseville, Editor-in-Chief

Produced by: Bailey Sasseville (Editor-in-Chief), Daisy Ritenour (President), Maria Rhine (Business Manager), Dakota Kolbe (Vice President), Carolyn Maxwell (Volunteer Coordinator), Josie Baker (Communications Member) and Emma Souza (Communications Member).

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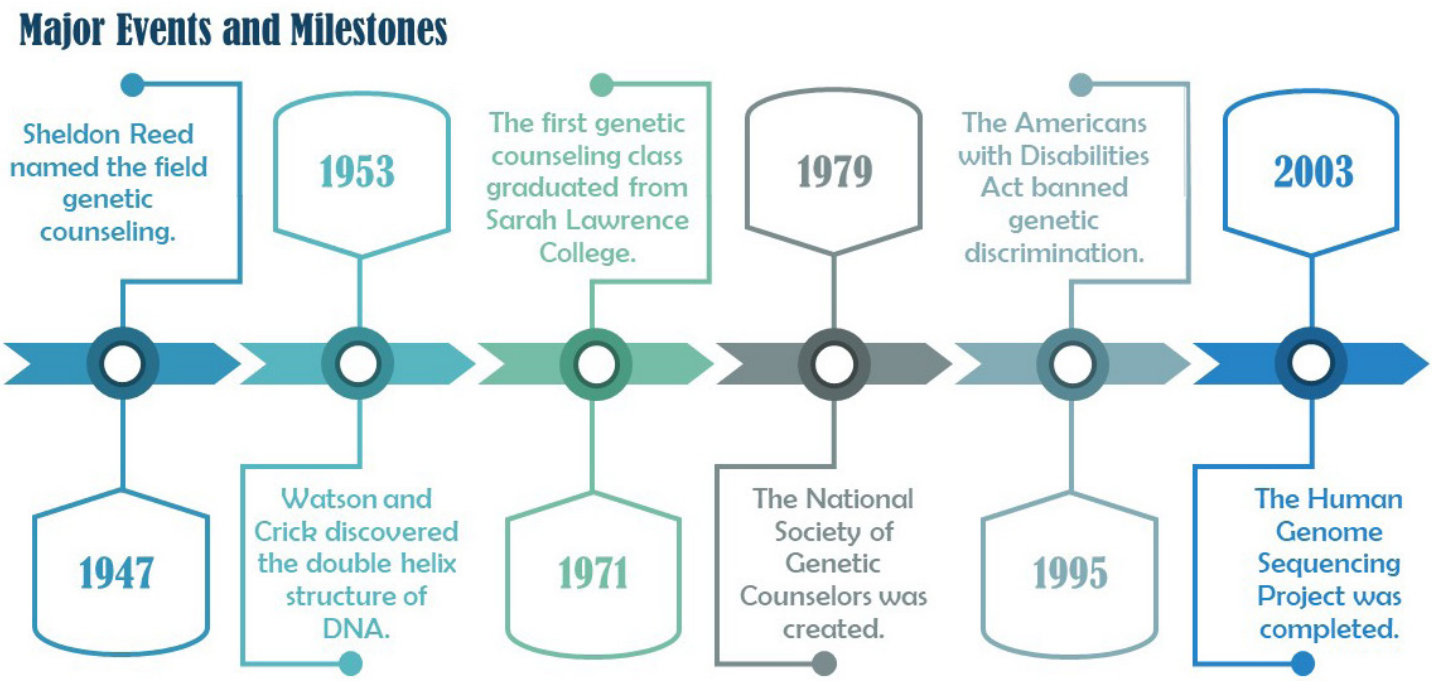
Genetic Counseling 101



By Daisy Ritenour

Genetic counseling is a health-care career that is centered on helping patients by providing information about genetic risk factors and available genetic tests, as well as providing emotional support. As defined by the National Society of Genetic Counselors, a genetic counselor is a professional who has specialized education in genetics and counseling to provide personalized help to patients as they make decisions about their genetic health.

How was the field of genetic counseling created?

Genetic counseling was born out of the eugenics movement, which peaked in the United States during the 1920s and 1930s. The end goal of the eugenics movement was to improve the human race by only allowing those who were deemed "fit" to reproduce. While the eugenics movement is typically associated with Nazi Germany, at one point in the 1930s the majority of U.S. states had sterilization laws targeting the poor and minority groups. Despite the negative beginnings, the field started to blossom in the late 1940s when Sheldon Reed first coined the term "genetic counseling." In opposition to the eugenics movement where patients had little influence on medical decisions, genetic counselors practice a nondirective approach that provides the patient with the information needed to make an informed decision. Every decade since has seen tremendous growth in the knowledge and technologies available to diagnose genetic disorders.

What does the field of genetic counseling look like today?

Today there are nearly 5,000 certified genetic counselors in the United States — there was a 100 percent increase in the amount of certified genetic counselors between 2006 and 2018. There are three main subspecialties: prenatal, pediatrics and cancer genetics. The largest subspecialty is cancer genetics, followed by prenatal genetics. Additionally, there is a wide variety of subspecialties including metabolic disease, cardiology and neurological genetics.

The majority of genetic counselors work in a university-owned medical center, a hospital or a laboratory setting. While most genetic counselors provide direct patient care and typically work in a clinical setting, approximately 25 percent of genetic counselors do not and typically work in a research setting.

There are currently 46 accredited genetic counseling programs in the United States and Canada, but more programs are being created every year. Genetic counseling graduate programs are two years long and involve a combination of classroom learning and clinical exposure. After receiving a master's in science, students take the American Board of Genetic Counseling national certification exam to become certified genetic counselors.

Where is the field of genetic counseling going next?

According the U.S. Bureau of Labor Statistics, there is expected to be a 29 percent growth rate of genetic counseling positions from 2016 to 2026. Further, the average salary of a genetic counselor, approximately $88,500, has increased 8 percent over the past two years and is expected to continue to increase.

Advances in technology have revolutionized genetic testing. The National Institute of Health estimated the sequencing of first human genome cost approximately $3 billion. Now, a human genome costs less than $2,000 to sequence and it is predicted that the cost of whole genome sequencing will continue to decrease. As these high-throughput sequencing technologies continue to lower in price, whole genome and whole exome sequencing are likely to become the leading genetic tests.

While the exact future of genetic counseling may be unknown, it is clear the dynamic career field will experience tremendous growth and expansion in the coming years.

Graduate School Spotlight: The University of Pittsburgh School of Public Health

By Daisy Ritenour

Cost: 1st year - $13,819 (in-state); $22, 726 (out-of-state)
2nd year - $4,630 (in-state); $7,714 (out-of-state)
Class Size: 10 to 12 students
Curriculum Summary: 1st year - primarily classes; 2nd year - primarily clinicals

Pitt's Genetic Counseling Graduate Program stands apart because of its rich history, varying clinical opportunities and unique dual degree possibilities. Pitt's program was created in 1971, making it the second oldest program in the United States. The longevity of the program has allowed for a broad and extensive alumni network with graduates all over the United States as well as abroad.

Pittsburgh is a diverse city with potential patients from all types of racial and social backgrounds. This diversity allows students to encounter a wide range of disorders, diseases and people during their clinical rotations. Students see on average 150 to 200 cases during their 13 blocks of clinical rotation. Further, there are two primary health networks within Pittsburgh, Allegheny Health Network and UPMC Health Plan, creating an extensive array of possible clinical locations. Students of Pitt's program have 40 potential clinical sites to choose from.

Equally as impressive, Pitt is one of the few schools to offer dual degree and certificate possibilities. Pitt's program is located within the School of Public Health, so students have the option to enroll in the dual degree program and receive a Master's of Science in Genetic Counseling and a Master's of Public Health. Students also have the option to earn a certificate in Public Health Genetics or Global Health.

Overall, Pitt's Genetic Counseling Graduate Program is one of a kind for a multitude of reasons. Pitt's program has endured for almost 50 years, yet has adapted and evolved to include a variety of certificate and degree options. Additionally, the program is located in Pittsburgh, the second most livable city in the United States. Pittsburgh features a variety of museums, cultural events and a strong sports following. Students of Pitt's program also receive an ID that grants them free public transportation on the Pittsburgh Port Authority buses, light rail and inclines.

Learn more about the University of Pittsburgh's Genetic Counseling Graduate Program here.

Genetic Counseling Grad Programs Prerequisites

By Maria Rhine and Daisy Ritenour

When applying to genetic counseling graduate programs, the courses listed below are generally required before admission. These prerequisites do not necessarily need to be completed before submitting an application. However, the applicant will need to provide a transcript of all completed prerequisites before enrollment. Additionally, some programs only allow you to take one of the required classes after submission of your application (i.e. spring semester of your senior year.) Programs typically require prerequisite classes be completed with a grade of a C or better.

Some programs may require other specific courses — for example, Northwestern University has molecular or cell biology listed as a prerequisite for its program. In addition, many programs have suggested coursework listed on their websites that they believe will aid in preparation for graduate school classes but are not a requirement for admission. These classes include anatomy and physiology, counseling, social work and others.

With completion of above mentioned courses, admissions committees will see a solid foundational knowledge necessary for entering a genetic counseling master's program.

Common Prereqs	Uncommon Prereqs
Biology	Molecular Biology
Genetics	Cell Biology
Chemistry	Developmental Bio
Organic Chemistry	Anatomy & Physiology
Biochemistry	Developmental Psych
Psychology	2nd Language
Statistics	Calculus

On top of academic prerequisites, there is a list of other experiences and documents graduate programs require in order to gain a more holistic view of an applicant. Most graduate programs require students to have taken the Graduate Record Examination. A score anywhere from the 50th to the 70th percentile can be competitive depending on the program. Additionally, a personal statement typically touching on why the applicant is interested in genetic counseling is also required. The average length requirements for a personal statement range from one page to four pages. Complementary to these, applicants will submit a curriculum vitae or a resume. This one to two page document should address any previous exposure to genetic counseling as well as any relevant work, volunteer and leadership experiences. Finally, some form of advocacy or counseling experience is generally recommended because it shows that an applicant has had previous experience in a supportive role similar to that of a genetic counselor.

Graduate Student Spotlight: Jessica Feldman

By Dakota Kolbe

Jessica Feldman, 24, is a Pitt alumna, current genetic counseling student at the University of Cincinnati and Cincinnati Children's Hospital Medical Center and co-founder of the Genetic Counseling Club at Pitt. Originally from Berks County in eastern Pennsylvania, Feldman moved to Pittsburgh to study biological sciences at the University of Pittsburgh. There she also minored in music and chemistry and earned a certificate in American Sign Language, all while maintaining a robust extracurricular calendar. While a student at Pitt, Feldman participated in a number of organizations around campus and the greater Pittsburgh community. She was a tutor and business manager for the American Sign Language club, member and business manager of Pitt fencing and worked as a peer educator/facilitator in the Stress Free Zone and the Emerging Leaders program. She also spent considerable time volunteering for Pittsburgh Action Against Rape's crisis hotline.

After graduating, Feldman worked for a year as a genetic counseling assistant at the Children's Hospital of Philadelphia in the Division of Metabolism and then moved to Cincinnati to pursue her Master's in Genetic Counseling. She has kindly agreed to be interviewed about her gap year and application experience for our publication.
Edits have been made for clarity and length.

Q: What factors influenced your decision to take a gap year?
A: There were a couple reasons, really. When I graduated, I was very burned out from school; even if I would have gotten into a program, I don't think that I would have absorbed or enjoyed the material I was learning. I felt that I really needed to see what life was like outside of school. I also felt that I didn't have the time I needed to get my application together, I wanted to bring up my GRE scores and that all can be a lot during senior year!
Q: What did you do while on your gap year?
A: I spent most of my time working as a Genetic Counseling Assistant (GCA) for the Division of Metabolism in Children's Hospital of Philadelphia. I worked with another GCA and two part time Genetic Counselors. I spent a lot of time interacting with patients and doing paperwork, I also did some research.
Q: Would you recommend a gap year to prospective students?
A: If you need it! It's definitely a difficult and personal decision. Time between undergrad and grad school is very common for Genetic Counseling, but not a requirement. It was great for me because I could come into grad school much more refreshed and ready to learn. Some people need that, some don't. I'm also glad for the time to work as a GCA.
Q: What advice would you give to a student taking a gap year?
A: Make sure that you are able to show that you are working on building your resume. There are a ton of reasons for taking a gap year from needing a break to saving money. As long as you can show that you were working on learning and growing as a potential genetic counselor you won't be at any disadvantage.
Q: What factors influenced where you applied?
A: Everything. You have to weigh everything from commute distance to history to location. It all matters. I applied to 7 schools. The four most important things for me though were cost, class size, rotation options and what other certification and programs the school offered. I wanted classes of around 8-12 with a wide range of rotation options, either in specialties or different sites, that narrowed it down a lot. I also knew I didn't want to go into a lot of debt so that affected where I applied. I also looked at what other programs the schools offered. Pitt has a Public Health program option, Northwestern and Case Western had a bioethics program that I was very interested in. There are a ton of things to consider and different things matter to different people.
Q: Why did you choose Cincinnati as your program?
A: The impressions I got while interviewing were huge for me. I felt very comfortable on campus while taking the tour, I would see myself working and studying there. I also paid attention to what questions they asked, who was made available to the interviewees, how the day was organized, what the campus was like, those kinds of things. I did pay attention to the city and the cost of the program too though.
Q: What is one thing you know now that you wish you knew when applying?
A: Traveling takes time! I was applying to schools that were very far from Philadelphia, and I forgot how much time, energy and money it takes to fly everywhere so plan ahead!
Q: What is the most interesting part of your GC program?
A: We have our own desks in the Human Genetics Department at CCHMC, which are next to the working Genetic Counselors, some of our professors and physicians! We also get student and hospital privileges!
Q: Relative to your undergraduate experience at Pitt, how challenging is graduate school?
A: Challenging! The Coursework is probably overall about the same but you have so many other aspects to balance. Clinicals, thesis meetings, all of those things take a lot of time. In terms of course difficulty though I feel Pitt prepared me well, especially Genomics, Developmental Biology and Human Physiology.
Q: Before we have to go, are there any interview tips you have for any prospective students?
A: Be yourself! I know it's super cheesy but it's true; if you've been asked for an interview they want to know who you are as a person. Don't be afraid to talk yourself up and make yourself stand out. Always have one question for your interviewer at the end. And for people who like to wear heels, bring walking shoes! Some interview days can last 7+ hours, I was happy I brought flats for the walking tours.

The Eboard and Communications Committee would like to thank Jessica for her willingness to make time for this interview. If any reader has questions for Jessica they may contact her via email at jessica.feldman@cchmc.org.

Considerations for Genetic Testing

By Carolyn Maxwell and Josie Baker

The expansive insights into your personal health that genetic testing provides are what make genetic counseling such a rapidly growing field. At the same time, patients often don't understand the process of testing or the possible results because of the ever-changing knowledge of genetics.

There are three possible results a genetic counselor may receive after ordering genetic testing: positive, negative and variant of uncertain significance. A positive test result means there is a malignant variant of the target gene based on previous studies and associations. A positive result, or a malignant change, could confirm a diagnosis or increase the chance of developing a disease in the patient's future. However, a positive test result does not always mean there is a 100 percent risk of developing a disease, because many other factors play into an increased disease risk. Next, a negative test result means there is no variant in the target gene. A negative result indicates the patient does not have a disease caused by a mutation in the tested gene, an increased risk of developing the disease or is not a carrier for a particular mutation. Lastly, there is a result that lies in the middle of the positive and negative result. This outcome is called a variance of uncertain significance, or VUS, which is considered inconclusive because there is a change in the target gene, but there is not significant evidence to classify it as malignant. This result cannot confirm or rule out a diagnosis.

Patients in the prenatal setting are either thinking of having a child or are already pregnant. In a preemptive counseling session, carrier screening will often be discussed with a couple to find out if two parents are carriers of the same autosomal recessive disease, in which case the child would have a 25 percent chance of having the disease phenotype. When a patient is already pregnant, the couple is often referred to genetic counseling because of abnormalities found in the fetus through an ultrasound. There is a range of what these abnormalities entail: there is a less severe end in which fetus measurements on ultrasound are different from the average, to the more severe end when a fetus has bodily functions not developing. There is a multitude of potential options that vary based on the patient's situation. A genetic counselor typically asks questions such as "What would you do with the information if your genetic testing came back positive?" which can be important for patients to fully understand why they personally do or do not want testing. Genetic testing can help patients decide if they want to terminate a pregnancy or help the patients prepare to care for a child with different needs. Another common response to this question is the patients would not change the management of their pregnancy, and do not want genetic testing. There is a great diversity of possible options depending on whether the patient decides to get genetic testing and on the consequences of the genetic variant found.

Pediatric genetic counseling is often one of the final steps in a long quest for answers about health issues that decrease in a child's quality of life. Genetic testing is performed to identify a root cause of many clinical features and health concerns that may be associated. This information can sometimes assist in identifying the best treatment plan. Genetic testing is sometimes required by doctors before a child can receive essential surgery due to risks that could be associated with certain genetic disorders. This also relates to ensuring the best care is being provided to a child. One reason testing may be delayed is because the testing may interfere with other pressing health issues that may be needed taken care of first.

In a cancer genetics setting, patients are seen because they either have cancer or have a family history of cancer. Both sets of patients will have a panel of genes commonly associated with their cancer history or symptons tested. For patients who already have cancer, identifying specific mutations can allow for more tailored treatment options. As for patients with a family history of cancer, if a mutation is found in a patient their management plan may change to include increased screening measures and preventative procedures. Patients will then have to consider the implications of telling other family members, who are also at risk of having this mutation. If a certain cancer gene is identified, other members of their family may want testing to see their associated risk. Family members may not want to be tested because they do not want to live their life with the burden of knowing they have an increased risk of cancer.

A hypothetical example of this would be the case of a mother with rare ovarian cancer who has recently tested positive for a mutation in the *BRCA1* gene, which increases the risk of developing breast and ovarian cancer. She has two daughters, one of whom has a family already and is not planning on expanding and one who wants to have a family of her own one day. If the daughter who does not have a family received testing and it came back positive for this same mutation, this might influence her future decisions about having a family in fear of passing down this mutation or wanting a preventative surgery to remove her ovaries. As for the daughter who already has a family that she does not want to expand, if she were to test positive for the mutation, she could opt for more frequent screenings or preventative surgeries without worrying about no longer being able to have children. For some people, this information is important for themselves and their future family plans, but others do not want this information to restrict their future decisions so they do not receive testing.

When considering genetic testing, it is important to be aware of the Genetic Information Nondiscrimination Act. This federal law was established in 2008 to protect individuals against discrimination in employment and health insurance in regard to genetic information. Genetic information helps individuals understand personal health conditions among themselves and their families and can be useful when deciding proper medical treatments and management of health care. GINA prevents health insurers from using genetic information against individuals when deciding eligibility and cost of health insurance. It is illegal to deny coverage based on genetic information or influence a certain cost for coverage. Also, GINA protects individuals from genetic discrimination in employment. It is illegal to use genetic information to be the determining factor based on hiring, firing or privileges among employees. Further, GINA makes it illegal to mistreat an employee based on genetic information. GINA supports equality in opportunities to gain health insurance and employment status as it realizes genetic testing and information is important to when making life decisions.

Genetic Counselor Spotlight: Elena Kessler, MS, CGC

By Bailey Sasseville and Carolyn Maxwell

There is no better way to get insight into the field of genetic counseling than shadowing and interviewing a genetic counselor. Due to the busy nature of many genetic counselors, these opportunities are sometimes hard to find. In an effort to make experiences like these more accessible we decided to interview Elena Kessler, a pediatric genetic counselor at Children's Hospital of Pittsburgh.

In each discipline of genetic counseling a "typical day" looks different, but Kessler emphasized that no matter what discipline you enter there is a lot more background work than people outside the field might realize. "A lot of our jobs is also prepping for those clinic patients or after the clinic patient, figuring out what testing we're ordering, filling out paperwork, requisitions," Kessler said. Kessler devotes several days per week to seeing patients in clinic. On these days Kessler sees typically eight patients, compiling a detailed medical and family history and providing any counseling needed for each. From there a doctor goes in to see the patient for a physical exam and then Kessler comes into the room again to discuss any testing options the doctor recommends and what the next steps are. On top of this Kessler works with two speciality clinics involving sickle cell and pediatric oncology. As Kessler summed up, "we wear many hats," and with a dense caseload, these many hats can be stressful. At the same time, these different hats bring a lot of diversity to each day and the job never gets boring.

Kessler was especially enthusiastic about the these speciality clinics. CHP has a large sickle cell program which offers multiple clinics every week. Kessler attends one each week and talks with new mothers who have a child with sickle cell as well as older kids with sickle cell ranging from ages 17 to 21. Her role is to educate new mothers and reeducate kids on the genetic component of sickle cell. "It's good to just sort of be a reminder and reeducate the older kids but then provide that fresh education to the new moms, who maybe are encountering this for the first time," Kessler said. For new mothers this involves discussing why their child has sickle cell and what the risks are for potential future children. Kessler said older children "are really really knowledgeable about the condition but sometimes that genetic piece falls by the wayside," so Kessler explains what sickle cell means for their future families and what risks are associated.

Kessler started the pediatric oncology program last year at CHP and it's one of about 30 in the nation. Though there are very few programs, "recent studies estimated that maybe 10 to 50 percent of kids that have cancer actually have a genetic predisposition," Kessler said. Before the program, children with cancer or a family history of cancer that increases their risk might fall through the cracks and never be referred to a genetic counselor. "But then we really got the word out, we went around to other specialties within the hospital and gave presentations about their patients and who would benefit from coming to see us, so now we get referrals from all over the hospital," said Kessler. With the implementation of this program there is now an increased awareness by both doctors and patients on the benefits genetic counselors can provide to pediatric oncology patients. Genetic testing can allow unknown cancer syndromes to be identified, which would lead to better treatment and proper screening, as well as giving the family more knowledge of the cancer risks that other members might have or pass on to their children.

One interesting case Kessler discussed was that of a teenage girl who presented with two different tumors, one sarcoma and one thyroid. Since this was a very unusual case in a young person, Kessler was brought on as a genetic counselor to help find the cause. After sending out a panel of about 50 genes to test, they found a mutation in a gene called *DICER1*, which was the cause of her cancers. Kessler said this result was reassuring to the family because with this gene "most of the tumors happen earlier in life, like in childhood or your 20s or 30s, but then typically you don't see them past 40." The doctors now can follow the specific screening recommendations for the *DICER1* mutation and the family has hope that these tumors may have been the worst of it, as opposed to a mutation causing high cancer risk throughout life. The girl's diagnosis also led to other family members getting genetic testing and those with the same mutation were then able to get screening and monitoring they might not have received otherwise.

Kessler said that the tests for *DICER1* were relatively new. "Had we had her two years ago we might not have had this result because this gene wouldn't have been on there." Many of the tests and testing techniques she currently uses are ones which didn't exist when she graduated from Pitt's genetic counseling program in 2010. "The field is exploding," Kessler said. She and other genetic counselors have to constantly work and read up on new tests and diagnoses to keep up. This also means that a patient whose illness might not be diagnosable by genetic testing right now could be diagnosed a few years down the road, so Kessler said part of her job is to explain this to patients and encourage them to follow up in a year or two. While constant growth of knowledge can be a struggle to keep up with, it is also a boon to the many people whose unknown diseases are becoming known. "We're finding diagnoses in kids that we would have never guessed of before, we would have never known, very rare things, and so I think we're able to give people more answers than ever before," Kessler said.

Being able to provide answers is Kessler's favorite part of genetic counseling. Even if the answer is not necessarily a positive one, Kessler said many families are grateful to know what exactly is wrong with their child and what the next steps are. "To help them through that process, to help educate them and guide them, you know, educate them about a diagnosis and help them understand where we go next, I think that's what is sort of my favorite part."

Listen to the full interview here.

Genetic Disorder Spotlight

Marfan Syndrome

By Josie Baker

Marfan syndrome is a genetic disorder that affects the body's connective tissue, which provides strength and flexibility to body structures including bones, muscles, ligaments and more. Connective tissues are important to everyday life as they assist in bodily functions. On average, 1 out of 5,000 individuals are affected by this disorer. Marfan syndrome is inherited by an autosomal dominant pattern, which means a parent must be affected by the syndrome and will have a 50 percent chance of passing it on to their child.

Marfan syndrome is caused by mutations in the *FBN1* gene, which encodes a protein called fibrillin-1. When this protein is functional, many proteins bind together to form filaments called microfibrils. These microfibrils form elastic fibers to provide strength and flexibility to the connective tissues. Additionally, microfibrils bind to molecules called growth factors which regulate growth and repair of tissues by releasing the growth factors at various times. When there is a mutation in the *FBN1* gene, the amount of functional fibrillin-1 protein available to form microfibrils is reduced. This leads to a decrease in microfibrils and elastic fibers and a decrease in regulation of growth factors, which causes overgrowth and instability of tissues.

Ectopia lensis. Credit: ARZTSAMUI/Shutterstock.com

Since connective tissues are found throughout the entire body, there are many clinical features that are associated with Marfan syndrome, but there are two primary features. The first one is ectopia lentis, which means the dislocation of the lens in the eye. The other feature is blood vessel abnormalities that cause the aorta of the heart to weaken and stretch. Eventually, this can lead to an aneurysm (a bulge in the blood vessel walls) or a aortic dissection (tearing in the aortic wall). These two major features are considered high-risk medical conditions if not found and treated properly. Some other clinical features associated with Marfan syndrome are loose joints, flexibility, elongated fingers and toes, arm span longer than body height, heart problems, stretch marks, curving of the spine and many more. These symptoms vary in the time of onset, severity and rate of progression.

Diagnosing Marfan syndrome begins with a physical exam completed by a geneticist, who will look for specific significant clinical features. If there are significant features observed, then the next step would be to have a connective tissues disorder panel ordered. This is a genetic test containing 67 genes associated with connective tissue disorders, including the *FBN1* gene responsible for Marfan syndrome. The test will determine if there is a malignant mutation in one of these genes that would explain the patient's current medical condition. Diagnosing Marfan syndrome is important due to the life-threatening medical outcomes, while proper treatment and screening allow individuals to live a normal lifespan.

Living with Marfan syndrome requires day-to-day management to provide the best quality of life. In many cases, regular treatments and physical activity guidelines are necessary to prevent medical conditions from worsening, such as prohibiting activities that could place stress on the already-weakened heart. For example, as previously mentioned, a primary feature of Marfan syndrome is the weakening of the heart muscles and tissues. A guideline for physical activity could include prohibitng activities that would place stress on the heart and worsen this condition. Current advanced treatments, research and screening can allow those living with Marfan syndrome to live a productive and successful life.

Progeria Syndrome

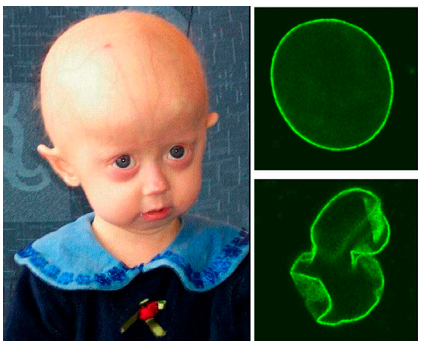
By Emma Souza

What is Progeria?

Hutchinson-Gilford Progeria Syndrome is an rare genetic condition that is characterized by the rapid aging of affected individuals. Progeria is not a heritable condition, but rather is caused by random mutation of the *LMNA* gene. The condition is so rare that it is almost never tested for prenatally. There is an approximate 1 in 4 million chance that a child will be born with progeria. To put this in context, as of August 2018 there were just 154 children with living with progeria in the world. Typically, parents find out that their child was born with progeria when their baby is around 18 to 24 months old. Despite facing such a difficult diagnosis, many individuals with progeria live fulfilling lives by spreading awareness about this disease and supporting others suffering

The Science Behind Progeria

In normal, unaffected individuals the *LMNA* gene expresses the lamin A protein. Lamin A is a scaffolding protein that is essential in maintaining the spherical shape of the nucleus, the small organelle inside eukaryotic cells containing DNA. Conversely, individuals who suffer from progeria have a deleterious mutation of the *LMNA* gene which results in a defective lamin A protein. This ultimately results in misshapen nuclei leading to rapid cell decay. For this reason, individuals with progeria have early-onset symptoms of aging, such as joint stiffness and hip dislocation. This is also the cause of a progeria patient's unique physical appearance. Often, an individual with progeria can be mistaken to be at least 65 years old when he or she is actually an adolescent. Other common characteristics of this condition are prominently set eyes, wide and/or elongated foreheads, a thin nose with a beaked tip, baldness, thin lips, low body-weight, a small chin and protruding ears.



These physical traits will become more apparent as the individual transitions from pre-pubescence to adolescence. However, even as an infant, it's likely that an individual born with progeria will look different than healthy newborns usually do. As the baby develops, parents will most likely become concerned as they

observe their child develop differently from others their age. The most significant internal feature of progeria is atherosclerosis, a condition which begins to develop at birth that causes the hardening of arteries, significantly increasing the risk of stroke and cardiovascular failure.

Finding and Maintaining Hope

With a handful of exceptions, children diagnosed with progeria have symptoms that worsen with age and typically only live until about 13. The oldest-living individual diagnosed with progeria was 26-year-old Leon Botha who lived a vibrant life as a South African DJ and artist and passed away in 2011. Despite their short life spans, a significant number of individuals with progeria — such as Hayley Okines and Sam Berns — inspire the world by spreading a contagiously positive attitude and and giving advice to anyone suffering — whether it be from a medical condition similar to theirs or simply a broken spirit.

To learn more about progeria and the extraordinary lives of individuals with this disease, you may consider getting a closer look at a few of these individuals' stories. Listed below are the works of several affected individuals who have passed since their publication.

- "Life According to Sam" | Filmed and directed by Sean and Andrea Fine
- "A Life to Celebrate" | Written by Hayley Okines and Alison Stokes
- "Young at Heart: The Likes and Life of a Teenager with Progeria" | Written by Alison Stokes

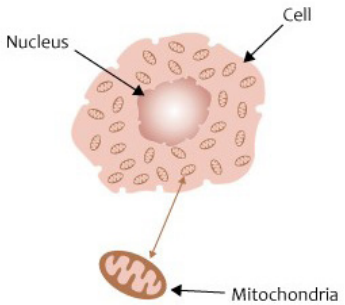
Special Topics in Genetics

Three-Parent Babies

By Maria Rhine

Most of us have heard the mitochondria is the powerhouse of the cell — this is emphasized because mitochondria account for around 90 percent of energy production in the body. When thinking about diseases associated with mitochondria, this important fact becomes much more complex. The mitochondria contain their own DNA which is inherited strictly from the mother. There are also mitochondria in every cell in the body (minus red blood cells), which means that mitochondrial disease is likely to affect multiple organs in the body. These diseases can affect each person in a unique way, making them extremely difficult to diagnose. They have a wide range of associated symptoms and disease patterns including seizure, stroke and inability to walk or talk. Diseases of this kind primarily occur in children and usually becomes suspect when three or more organs are involved, specifically the brain, muscles and lungs, the three most energy-demanding organs.

One type of mitochondrial disease occurs when there is an inherited mutation from the maternal line in one of the 37 genes encoded in mitochondrial DNA (mtDNA). Leigh's Syndrome is a neurodegenerative disorder that presents in children around 2 years old when they begin to exhibit loss of basic skills such as sucking, walking or talking. Children may become irritable, have appetite loss or seizures. Currently, there is no cure and a poor prognosis for those affected by Leigh's syndrome. One couple sought the help of a fertility doctor after suffering multiple miscarriages and losing two children to Leigh's Syndrome. This fertility doctor attempted the process of mitochondrial transfer, a phenomenon more commonly thought of as a "three-parent baby." The goal was to replace only the damaged mtDNA contained in the mother's egg to prevent it from being transferred to the baby. This was accomplished through a transplant of the mother's nucleus into a donor woman's egg cell containing no mutated mtDNA. The title "three-parent baby" is not extremely accurate because this procedure does not affect the DNA in the nucleus of the mother or father. The nuclear DNA from the mother and the father is what combines to create the 23 pairs of chromosomes, constituting nearly the entire genetic makeup of the baby. A healthy child was born in 2016 as a result of a successful procedure completed by the fertility doctor.



Since this child's birth, there have been a number of safety and ethical debates regarding the procedure. Are there side effects from having DNA from three people, even if only 37 genes were switched out? Can all the mutated mtDNA be removed from the egg or will the child still be susceptible to some symptoms? In terms of ethics, this new donor mtDNA could affect future generations in the family if the child born as a result of the procedure is a female, since mtDNA is passed through the maternal line. Before this technique is implemented as a legitimate treatment for mitochondrial disease, more research must be done on the safety of the procedure both for the child and future generations of the family.

What role do genetic counselors play the lives of families affected by mitochondrial disease? As always, genetic counselors are a support system to help work through the emotional difficulties surrounding struggles with infertility or transmission of a disease to offspring, but it is likely to be especially challenging with mitochondrial disease due to the difficulties in confirming a diagnosis. It is also safe to assume that if mitochondrial transfer ever becomes a valid procedure, genetic counselors would be a crucial source of information and a guide for parents considering this complex treatment. As science and technology continue to improve and aid our understanding of disease, genetic counselors will certainly continue to adapt to new approaches to maintain the ultimate goal of providing information and support to families at risk for genetic diseases.

Thank you for reading Issue I! We hope you check back next semester for Issue II!