Genetic Diseases and Karyotypes

Adapted from the National Institutes of Health
Lesson 4 - The importance of Medical Research
Today we are going to look at a case study of a girl who has a rare disease.

**Background**

Jason and Kim are the parents of a five-year old girl, Hanna. They are concerned because she has had flu-like symptoms for three weeks and has not responded to treatment. The family doctor was concerned that something more serious than flu might be responsible for Hanna’s symptoms. He referred Hanna to another doctor for further examination.

**First visit**

The doctor examined the child and immediately noticed that she had signs of an infection. She felt the child’s abdomen and observed that the liver appeared to be swollen. The doctor asked the parents about their daughter’s health and the health of the rest of the family. Finally, she ordered some blood tests.
What are the 3 causes of disease?

- Infectious Agents
- Heredity (genetics)
- Exposure to environmental toxins.
Let’s Do Some Research...

Each table has 4 minutes or less to go to their research station and look up the answer the question on the note card.

Write the answer on the post it note and bring it back to the front of the room. We will share the research results with the class.

1) What is genetic Mutation?
2) What are types of genetic mutations?
3) What is Leukemia?
4) What are environmental risk factors of leukemia?
5) What are biological causes of leukemia?
6) What are stem cells?
7) What are leukemia treatments?
Now that we’ve done some research let’s return to Hanna’s case.

Her parents and brother are all healthy.

- Does this rule out genetics as the cause of her leukemia?
- What about environmental exposure or infections as the cause?

So far we do not have a conclusive answer.

- How can stem cells lead to leukemia?
  - Mutations - inherited and new ones from environmental exposure and/or mistakes during cell division.
  - Some mutations cause genetic disorders and can be seen when scientists photograph the cells chromosomes and order them by size.
Let's look at a normal karyotype

A karyotype is a photograph of a person's complete set of chromosomes.

A healthy human karyotype shows 22 pairs of numbered chromosomes (arranged by size), where one member of each pair comes from the mother and the other comes from the father.

There is an additional pair called the sex chromosomes. An individual with one X chromosome and one Y chromosome is male. Someone with two X chromosomes and no Y chromosome is female.
Some genetic diseases can be diagnosed by visible extra copies of chromosomes in the karyotype.

What do you think we will find when we look at Hanna’s families karyotypes?

**Figure 1. Hanna.** (Genetics Department, Affiliated Laboratories, Inc., Bangor, Maine)

**Figure 2. Kim.** (Genetics Department, Affiliated Laboratories, Inc., Bangor, Maine)

**Figure 3. Rick.** (Genetics Department, Affiliated Laboratories, Inc., Bangor, Maine)

**Figure 4. Jason.** (Genetics Department, Affiliated Laboratories, Inc., Bangor, Maine)
Now let's look at karyotypes from Hanna's blood, cheeks, and hair.

What do you expect to see?
Use the rest of the time and computers to research other genetic diseases caused by chromosomal anomalies.

Don’t forget to sign up for the OPIHI field trip if you are interested. Today is the last day!
Are you Susceptible?

Adapted from the National Institutes of Health Lesson 5
What is RISK?

- Risk refers to the chance that something bad or negative will happen.
  - Risk involved in dangerous behaviors
  - Risk that something will happen
- Can you modify your risks?
  - Can you modify your risk of getting a heart attack, being robbed, or getting cancer?
Death of an Olympic Champion

Ekaterina Gordeeva and Sergei Grinkov, young Russian figure skaters, had won two Olympic gold medals in the pairs competition and were expected to continue dazzling audiences and judges for years into the future. In November 1995, however, 28-year-old Sergei suddenly collapsed and died during a practice session. He was a nonsmoker, he was physically fit, and there had been no warning signs. What happened to cause this young athlete’s early death?


Sergei Grinkov was born with a mutation called PL(A2) in a single gene that affects the formation of blood clots. The mutation causes clots to form in the wrong places at the wrong time. If such a clot forms in one of the arteries that supply the heart, a heart attack can result.

Do you think this mutant allele influenced Sergei Grinkov’s risk of a premature heart attack?
How could Sergei Grinkov modified his behavior had he known he was at risk for premature heart attack?

- Low cholesterol
- More exercise

Premature heart attacks result from single gene disorders are uncommon. Most heart attacks occur later in life and result from a combination of genetic and environmental factors that produce atherosclerosis, the buildup of cholesterol deposits in the arteries.

We are about to play a risk game to see how genetic analysis and people's risk of diseases work.
How many students suffered a fatal heart attack?

How is this game like real life? How is it not?

Now we are going to look at your risk factors and add in the genetic component.

Complete the Thinking About the Game worksheet based on your risk results with and without genetic components.
The Difficulty of Diagnosis

Adapted from the National Institutes of Health Lesson 3
Today we are investigating a case study of a child who has a rare disease.

To Play or Not to Play?

Patrick is a 13-year-old middle school student who loves to play basketball. He came home excited from school and explained to his parents that the school basketball team will be holding tryouts next month and he wants to participate.

Patrick’s parents are both happy and concerned for him. They are happy because they know Patrick loves sports, and they feel that the exercise will be good for him. They also know that Patrick has been occasionally teased because he is tall and thin. Maybe by joining the basketball team he will make new friends and feel more accepted by his classmates.

Patrick’s parents are concerned because he has some health problems. When Patrick was a toddler, the family doctor diagnosed him with a heart murmur. The doctor explained that a heart murmur refers to a sound that the blood makes as it flows through the heart. She further explained that heart murmurs are usually harmless and that Patrick could lead a normal life.
Would you allow Patrick to try out for the basketball team?

When he was nine, Patrick developed a problem with his eyesight, and it was discovered that one of his eye lenses was detached and had to be repaired. When Patrick was 10, he was diagnosed with asthma. The doctor explained that asthma causes the tubes carrying air in and out of the lungs to become sore and swollen. This can cause coughing and wheezing and make it difficult to breathe. The doctor created a treatment plan for Patrick that helped him recognize his symptoms and use an inhaler to make breathing easier. She also explained that, with proper management of his asthma, Patrick could play sports and that the exercise might even improve his condition.

Finally, just last year, Patrick was diagnosed with scoliosis, or curvature of the spine. The doctor explained that Patrick’s scoliosis was moderate and, as with most children, the cause was unknown. He further explained that in 90 percent of cases, no future treatment is needed.
The discussion about playing basketball and health promoted Patrick’s parents to look into the family's medical history.

Especially on Patrick’s father’s side of the family, some relatives have had medical problems similar to Patrick’s. Several have had serious heart problems. His parents are worried that inherited disease might run in the family.

Sometimes doctors can look into a family history and see an inherited disease and sometimes a person has a disease caused by a mutation unique to that individual.
Patrick and his parents visited a medical geneticist, a doctor who specializes in diagnosing people with genetic diseases.

In our first activity we will be splitting up into groups of 4 (table groups). Each member will assume a role of medical specialists (different systems) who assist the medical geneticist in diagnosing Patrick.

- Orthopedist (Skeletal System)
- Ophthalmologist (Visual System)
- Cardiologist (Heart and Circulation system)
- Pulmonologist (Respiratory System)
Group work Instructions - 20 minutes

- Read the information on the handouts.
- Record what you learn about Patrick’s medical history.
- Record what you learn from Patrick’s Physical Exam.
- Use the Medical Reference Manual section from each handout to learn about possible causes for Patrick’s medical problem and record them.

Share findings with the class.

Do you believe that Patrick’s various medical problems are connected and what evidence do you have to support that conclusion?
What is Connective Tissue?

- Connective tissue is largely made of proteins. It forms tissues that help hold organs in place, and it connects muscles to bones and bones to bones.
  - Skin is made up of a lot of connective tissue and allows it to be elastic.
- Gently pinch your skin on your hand or arm together and watch it return to normal. This shows the elasticity of your connective tissue in your skin.
- How might having looser connective tissue affect the body?
  - Having looser connective tissue can cause things like the heart valve flaps to change shape and not make a tight seal or the looser connective tissue can’t hold the eye lens tightly in place.
Remember Patrick’s medical symptoms involve more than 1 body system and that these symptoms seem to be related to connective tissue.

Today we are going to investigate some disorders that affect connective tissue and try to decide whether one rare disorder is more likely than the others to be responsible for Patrick’s medical condition.

You now have 10 minutes to complete the “diagnosing a connective Tissue Disorder” sheet with the help of the “Medical Reference Manual” and your shoulder partner.
What is your Diagnosis for Patrick?

<table>
<thead>
<tr>
<th>Patrick’s medical history</th>
<th>Ehlers-Danlos syndrome</th>
<th>Marfan syndrome</th>
<th>Osteogenesis imperfecta</th>
<th>Scleroderma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myopia</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detached eye lens</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collapsed lung</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart murmur</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaky heart valve</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long arms and legs</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curvature of spine</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

Marfan syndrome is a disorder of connective tissue that is due to mutations in a gene that codes for a connective tissue protein called fibrillin.
To complete Patrick’s diagnosis you have to see if there is evidence of Marfan syndrome in Patrick’s family by looking at his family tree.

Record any evidence that shows there is a history of Marfan syndrome in the family.

- Mother’s side of the family is free of any symptoms associated with connective tissue disorders and therefore not of any interest.
- There are definite signs of Marfan’s syndrome in Patrick’s family and his condition is inherited.
Living with Marfan Syndrome

Questions to a doctor from young people who have Marfan syndrome

1. “Is there any possible way for the Marfan gene to be detected before a child is born and maybe find a way to prevent it from mutating itself?”

2. “When they measured my heart with the echocardiogram, they told my mom they don’t think I should do marching band. I was wondering, if I don’t exert myself too much, if I take it at my own pace, do you think I could do it?

Comments from those young people about the most frustrating part of having Marfan syndrome

1. “The most frustrating thing for me is … I can’t drive. I tried to get my permit, and I couldn’t pass the vision test because I did have my retina detached.”

2. “The thing that frustrates me the most is all the aches and pains in my joints and sternum.”

3. “When it comes to how you’re socially accepted, high school is really lame. In a couple of years, it’s not going to matter what sport you played or anything. It is going to matter what you know and what you do with the knowledge that you know.”
Now that we have looked into the symptoms and causes of Marfan syndrome let’s think about this disease and how it affects those who have it.

In what ways might having Marfan syndrome affect your daily life?

How would you want to be treated by your classmates if you had Marfan syndrome?

Do you think Patrick’s parents should allow him to try out for basketball? Which is the better choice, restricting Patrick from basketball to prevent injuries or allowing him to live his life doing what he is passionate about. Pick a side and explain why or why not, use information from the lesson to support your answer. (must be 2 paragraphs long)