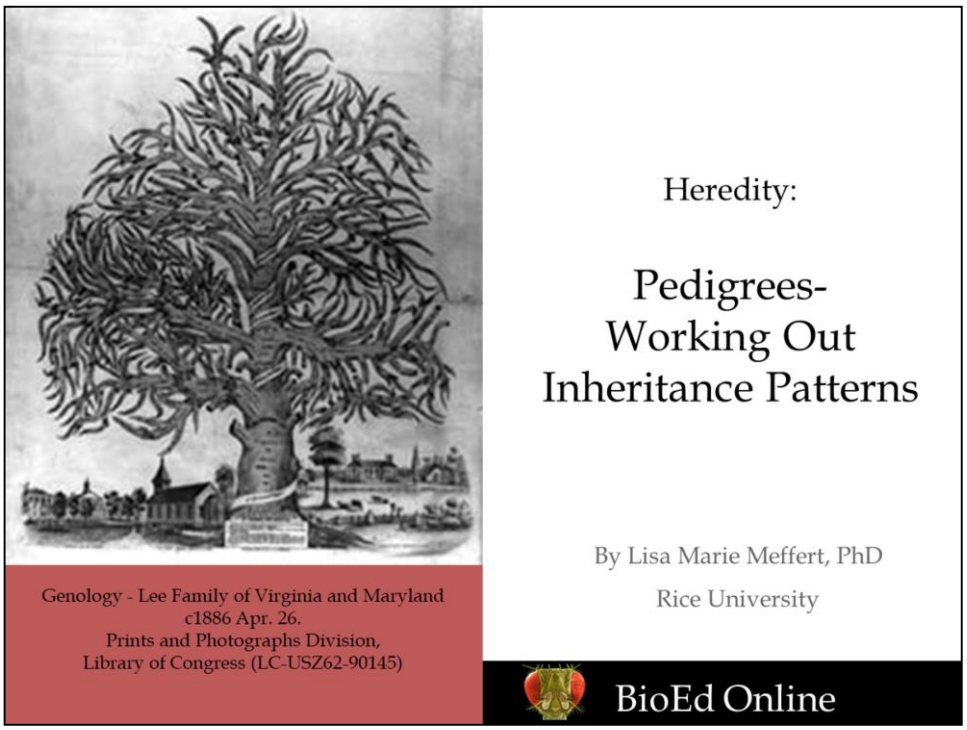
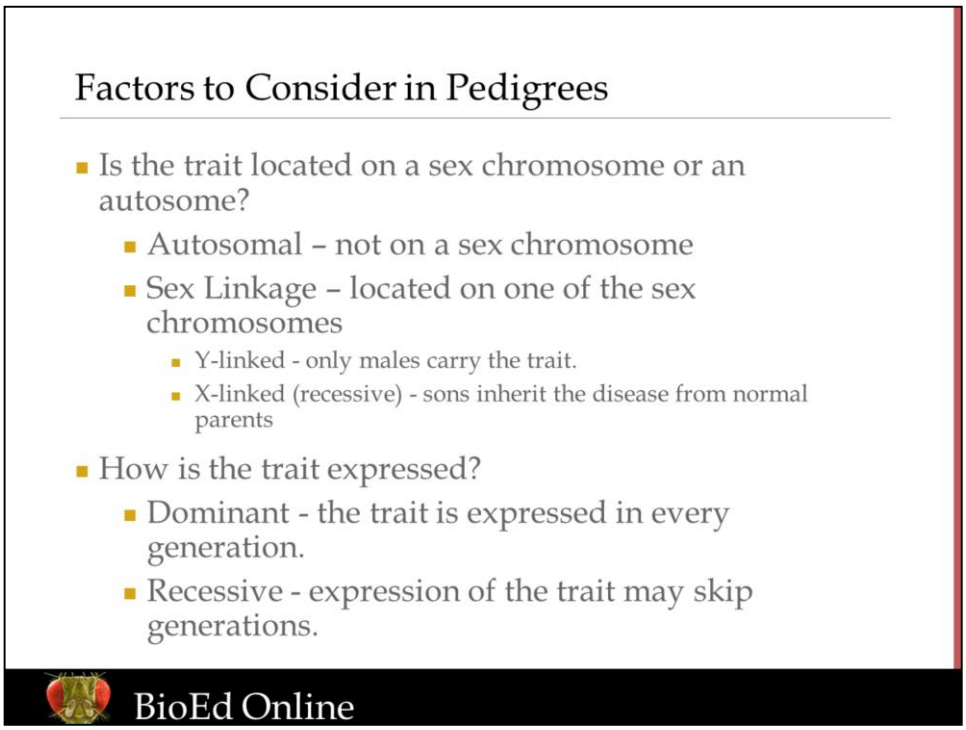


Image Reference

Lee family of Virginia and Maryland. United States Library of Congress.(c1886). Retrieved 05-20-2005 from http://www.loc.gov/rr/genealogy/



Factors to Consider in Pedigrees

In this module, we will go through the factors to consider in working out pedigrees. A pedigree illustrates a family history that shows how a trait is inherited over several generations. In the simplest pedigrees, a trait is considered either present or absent, such as with the expression of a disease.

The first step in working out simple pedigrees is to make sure the trait is autosomal (not on the sex chromosomes). This is done by looking for sex-specific trends in the expression of the trait.

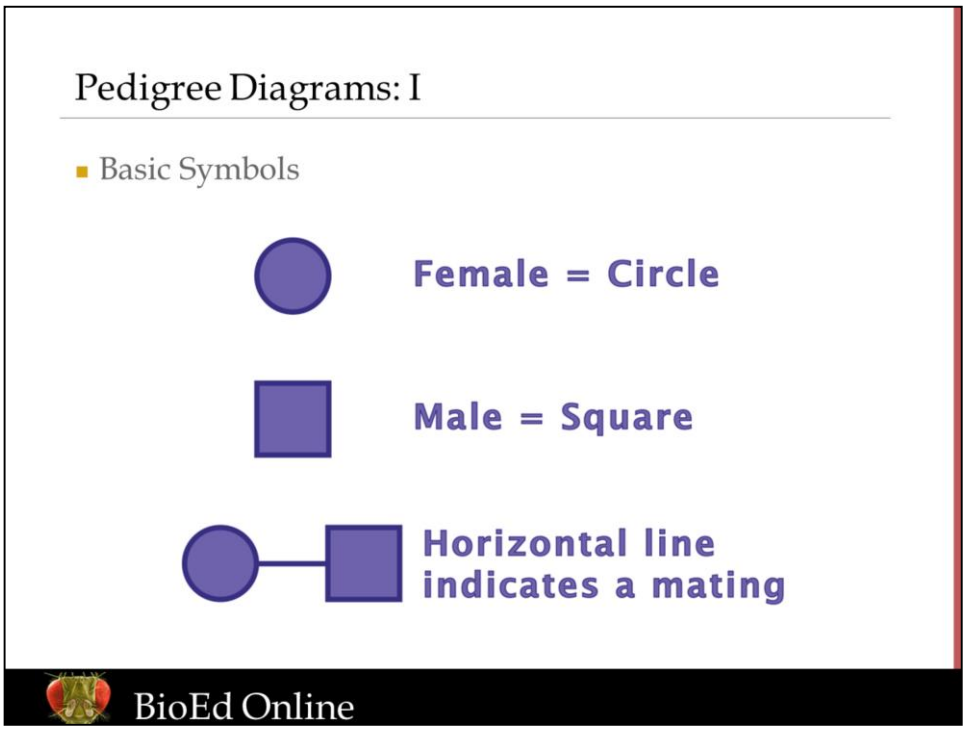
The second step is to identify the pattern of expression. Recall that a dominant allele masks a recessive allele. Dominant alleles are expressed every generation. For recessive alleles, the expression may skip generations.

Sex-specific patterns can be due to linkage to the X chromosome or the Y chromosome. Recall that in humans, two X chromosomes produce a female, while the X-Y combination produces a male. If the trait is Y-linked, any individual who expresses the trait also has to be male. Thus, if only males express the trait, the gene for the trait is on the Y chromosome. In a sense, Y-linked genes are always dominant, since there is no homologous (matching) gene on the X-chromosome that could mask its expression. For X-linked recessive traits, we find a bias for sons to inherit a disease from normal parents.

We will go through the four basic types of pedigrees: Autosomal dominant, autosomal recessive, Y-linked, and X-linked recessive.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.



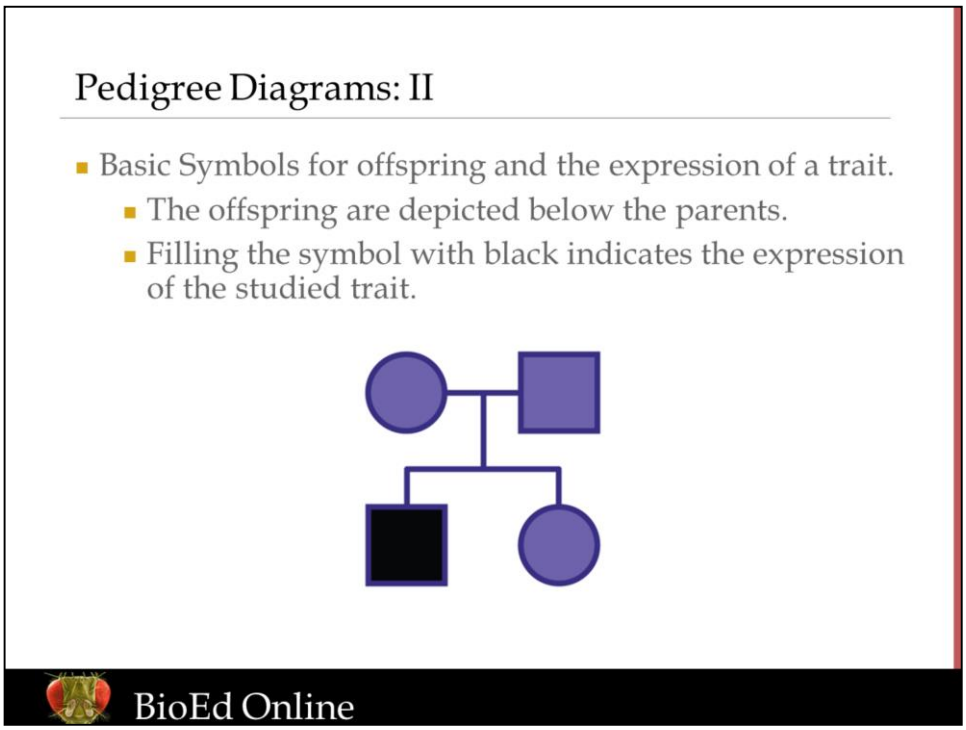
Pedigree Diagrams: I

Basic Symbols

There are several conventions that are followed in the representation of pedigrees. Traditionally, a circle is the **basic symbol** for a female. The **symbol** for a male is a square. A horizontal line connecting a male and female depicts a mating.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.



Pedigree Diagrams: II

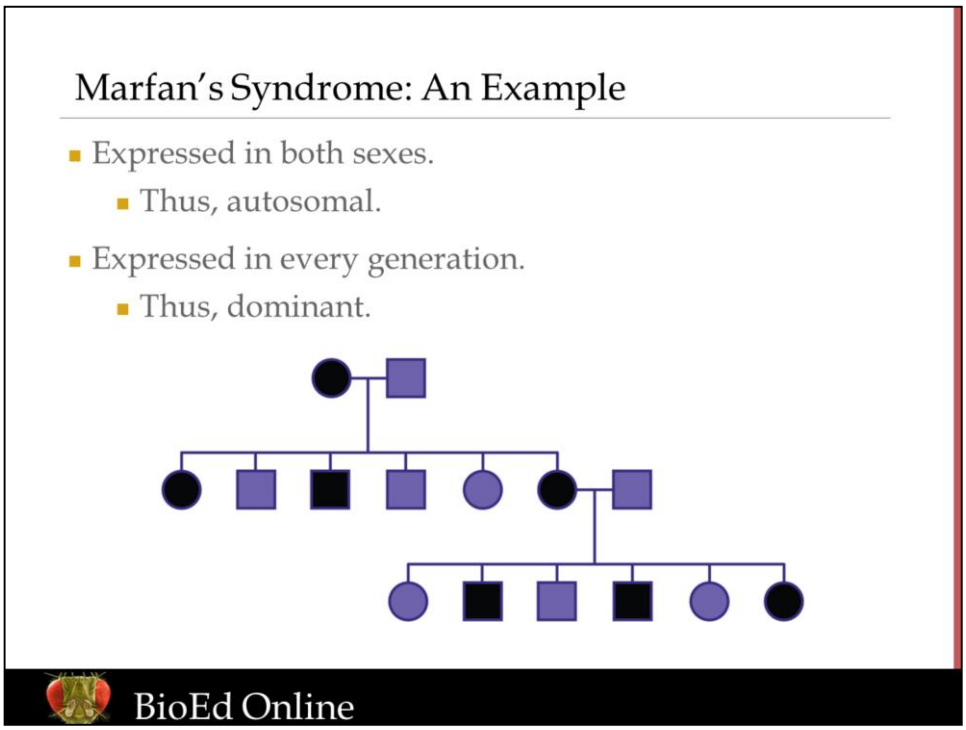
Basic Symbols for Offspring and Expression of a Trait

When drawing pedigrees, certain conventions are followed to depict offspring and their characteristics. The lines emanating from the mating line identify the offspring in the next generation. In this pedigree, the mating produced one son and one daughter.

A solid black symbol indicates the expression of the trait in question. In the pedigree above, only the son expresses the trait.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.



Marfan's Syndrome: An Example

Marfan's Syndrome is an example of an inherited disorder that can be followed in a pedigree. People expressing **Marfan's Syndrome** have hyper-elastic joints and elongated bones (among other features), as depicted in the photo. Note that in this pedigree, the expression of the trait has no sex-specific pattern. Both males and females express Marfan's syndrome (depicted by black circles or squares) at approximately equal frequency. Thus, we can assume the gene that causes Marfan's syndrome is autosomal.

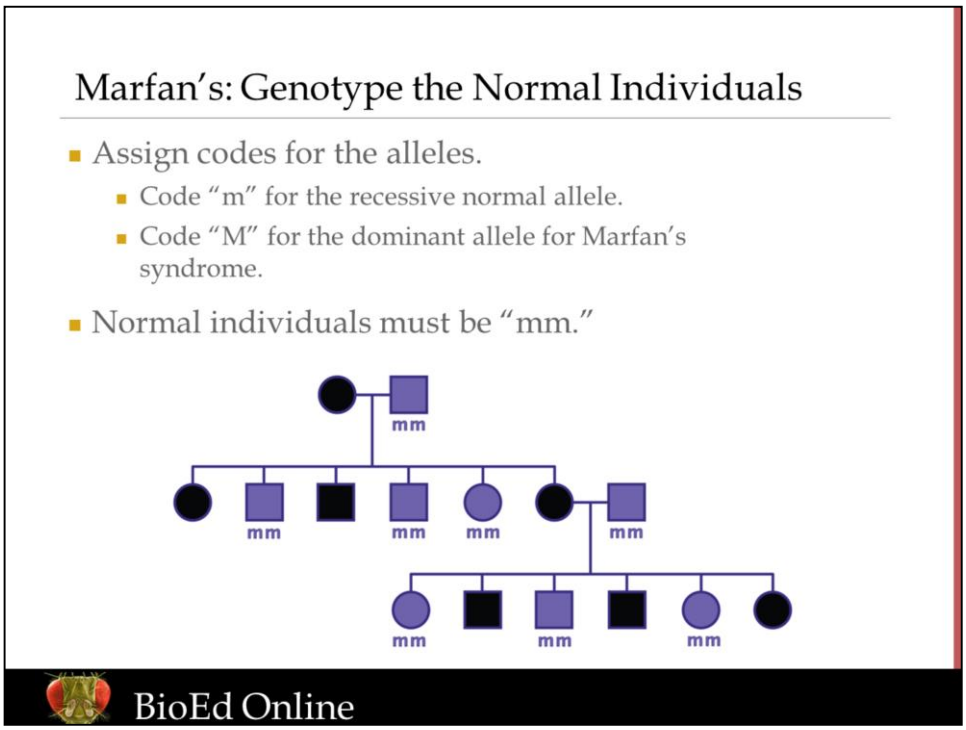
Next, note that the trait is expressed in every generation. Therefore, we assume that an allele for Marfan's syndrome is dominant to a normal allele. An allele is an alternate form of a gene. In the this case, for example, one form (or allele) of the gene is expressed as Marfan's Syndrome and the other allele produces normal joints and bone length.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Marfan's: Genotype the Normal Individuals

The first step for working out the pedigree for an autosomal dominant trait is to **genotype the normal individuals**. Here, we are using an arbitrary coding system of "m" for the recessive normal allele and "M" for the dominant allele that confers Marfan's syndrome. As noted in the previous slide, an allele is an alternate form of a gene.

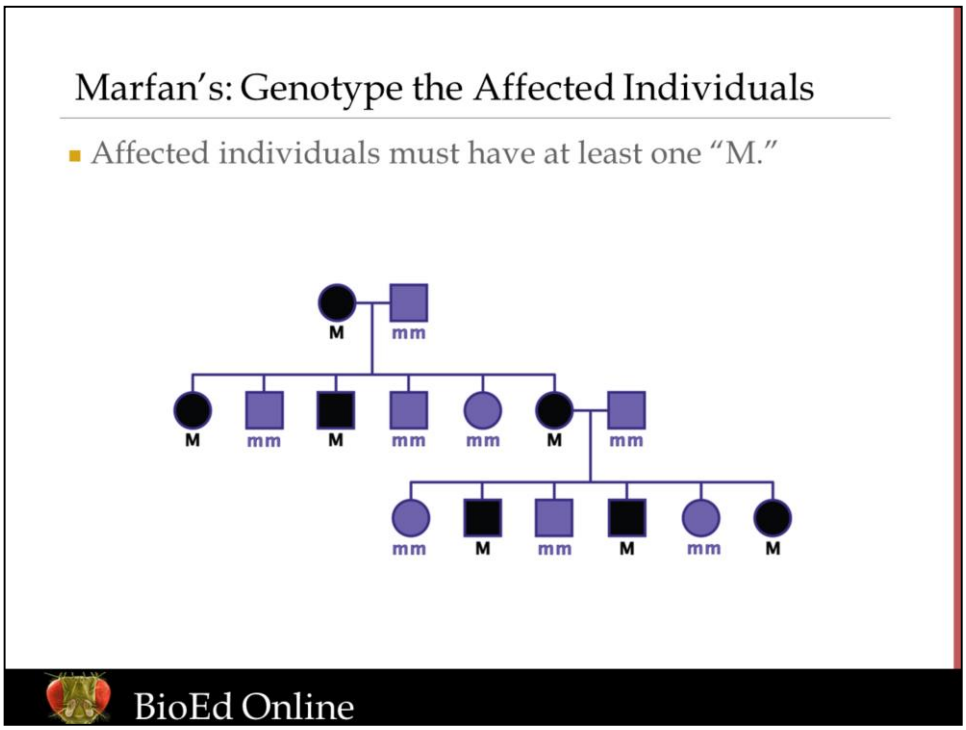
All normal individuals (purple circles and squares) must be homozygous for the "m" allele. Thus, we write the appropriate genotype below each normal individual in the pedigree. In general, genotype refers to the genetic makeup of an individual. Geneticists also use the term to refer to the process of identifying the alleles present in an individual. Phenotype refers to the observable characteristics of an organism.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Genotype the Affected Individuals

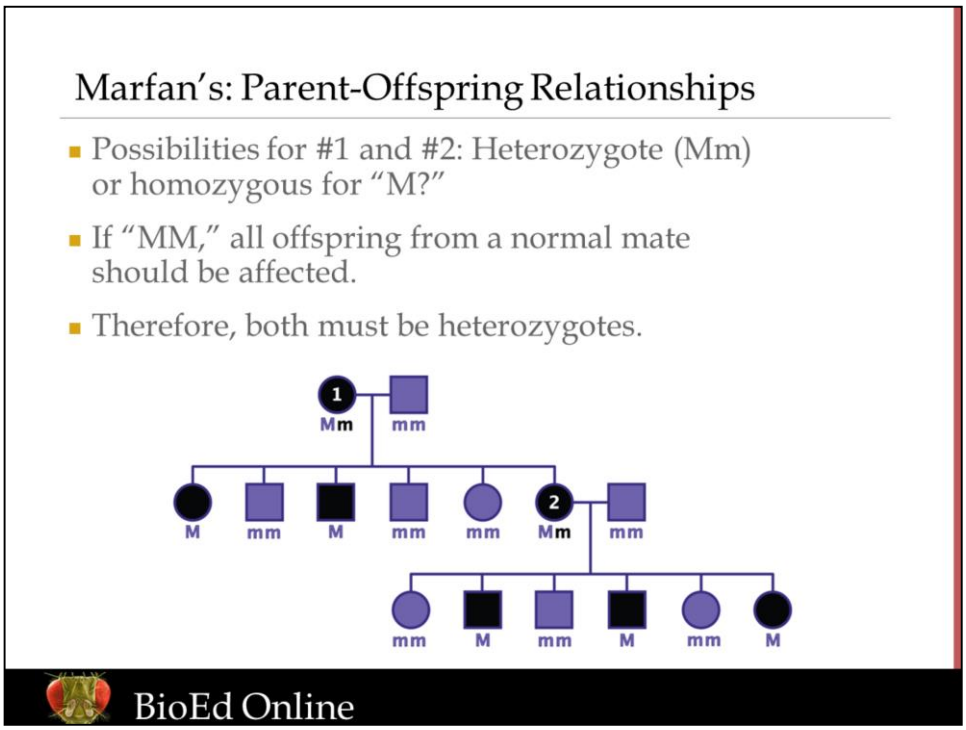
The next step is to **genotype the affected individuals**. Since only one "M" allele is sufficient to cause Marfan's syndrome, the genotype of any individual expressing the trait must have at least one "M" (see the notations in black).

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Parent – Offspring Relationships

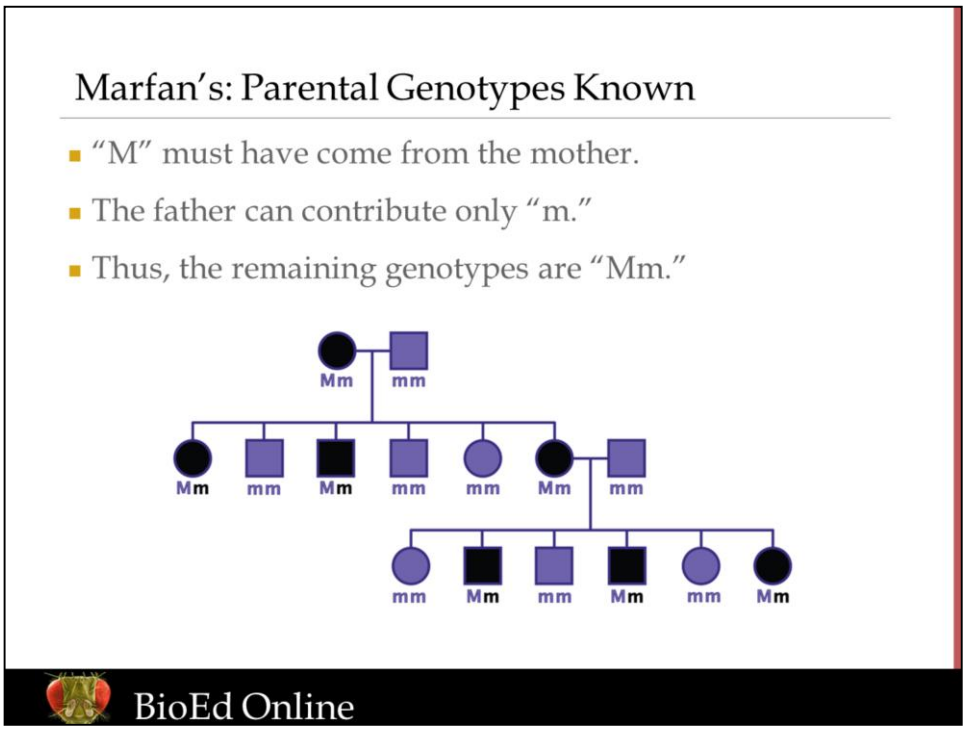
Now we will begin to consider **parent – offspring relationships**. At first glance, we do not know if individual #1 is heterozygous or homozygous for the "M" allele. However, note that when she mates with a normal male, she produces some normal offspring. Thus, we can conclude that she is a heterozygote. If she were homozygous for "M," then every one of her offspring would receive the allele for Marfan's syndrome. The same logic applies to assigning the genotype to individual #2.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Parental Genotypes Known

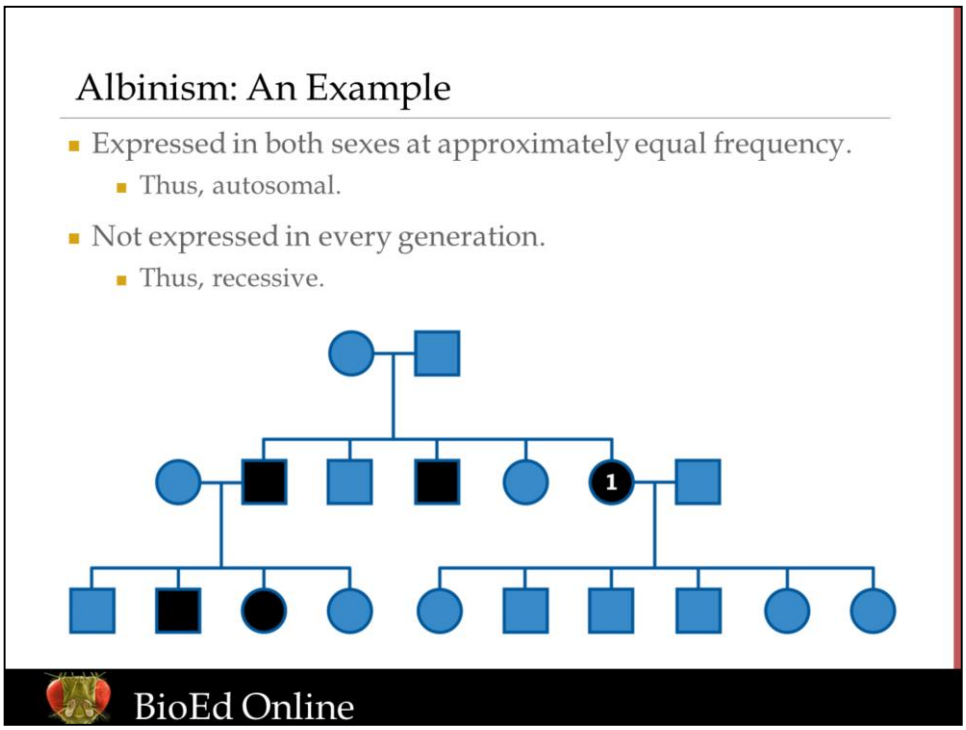
We now can focus on families where the **parental genotypes are known**. We know the remaining affected individuals must have received their "M" from their mothers, since their fathers were normal ("mm"" genotypes). Thus, their other allele must have come from their fathers. Since the fathers are homozygous for "m," each one of their offspring must have received an "m" allele.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Albinism: An Example

People expressing **albinism** lack pigmentation in their eyes and skin (among other features). As with the pedigree for Marfan's syndrome, expression of the albino trait has no sex-specific pattern. Both males and females express albinism at approximately equal frequency (the black circles and squares). Thus, we can assume the gene that causes albinism is autosomal.

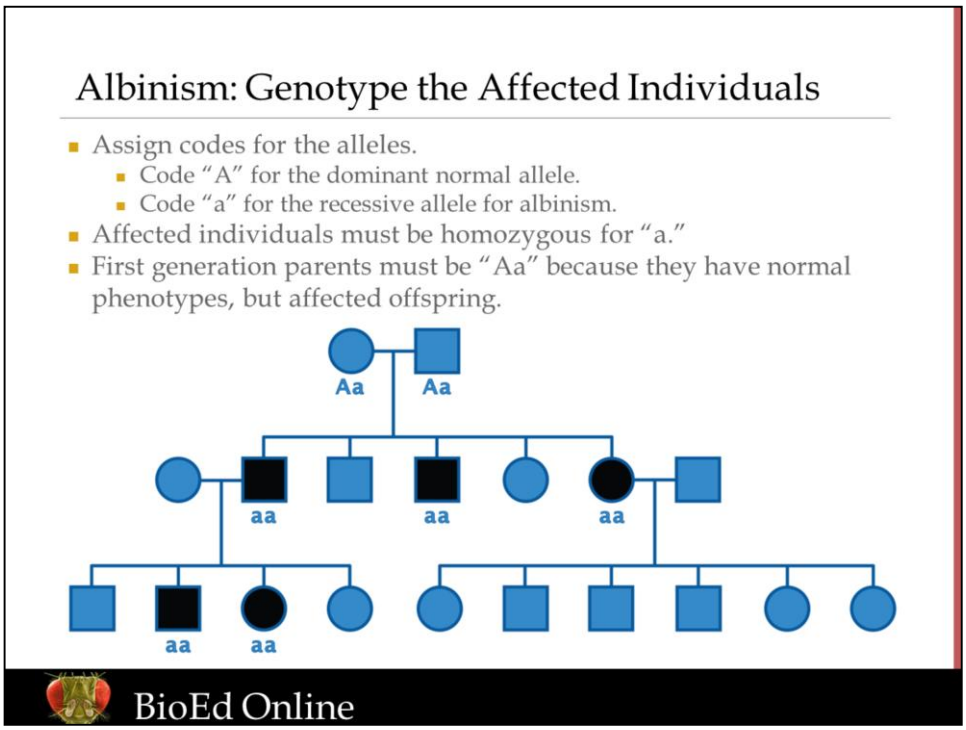
Note that the trait is not expressed in every generation. Neither parent in the first generation was albino, but the offspring were. Also, individual #1 expressed albinism, but this trait was not found in any of her offspring. Therefore, we can assume that an allele for albinism is recessive to a normal allele.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference:

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Genotype the Affected Individuals

The first step in working out the pedigree of an autosomal recessive trait is to **genotype the affected individuals**. Here, we are using an arbitrary coding system of "A" for the dominant normal allele and "a" for the recessive allele that confers albinism. Since both "a" alleles are required to cause albinism, the genotype of any individual expressing the trait must be homozygous for "a."

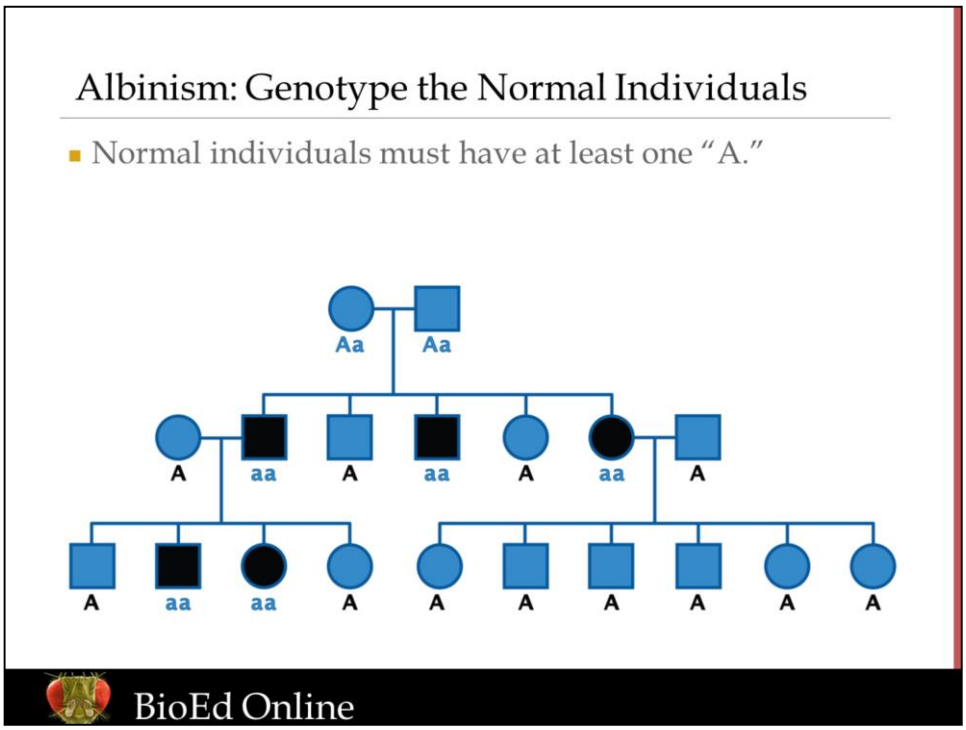
Because the parents of the first generation did not express albinism, we know they must have at least one "A" each. And since we know those same parents also produced affected offspring, we know they also must have at least one "a" each. Thus, the parents in the first generation must be heterozygotes.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Genotype the Normal Individuals

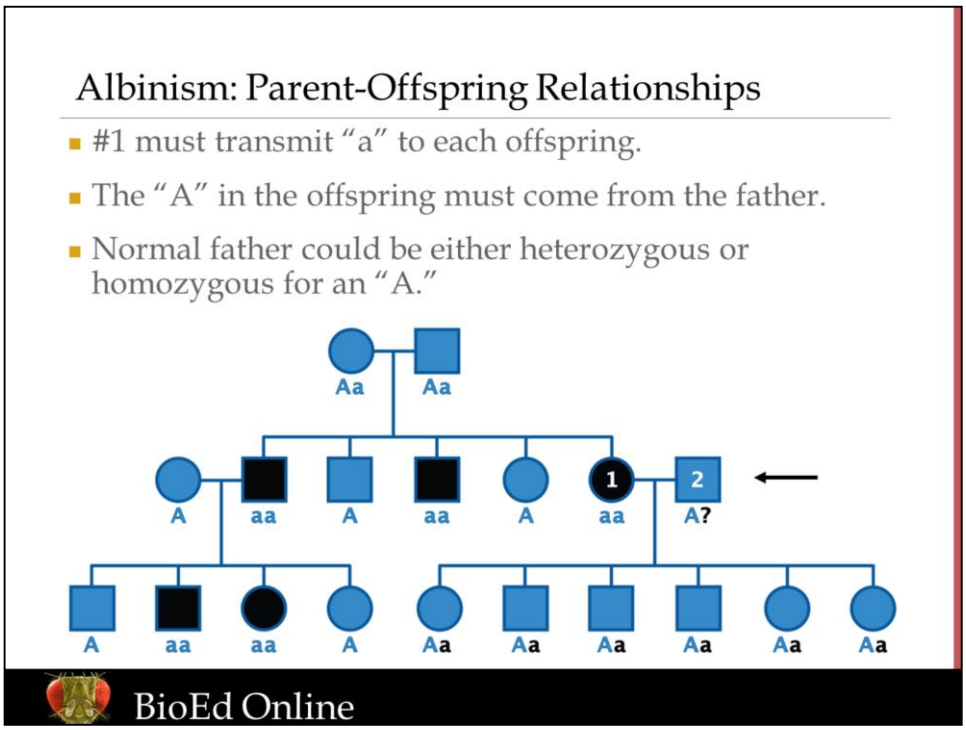
The next step is to **genotype the normal individuals**. Since only one "A" allele is sufficient for normal pigmentation, the genotype of any normal individual must have at least one "A" (see notations in black).

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Parent – Offspring Relationships

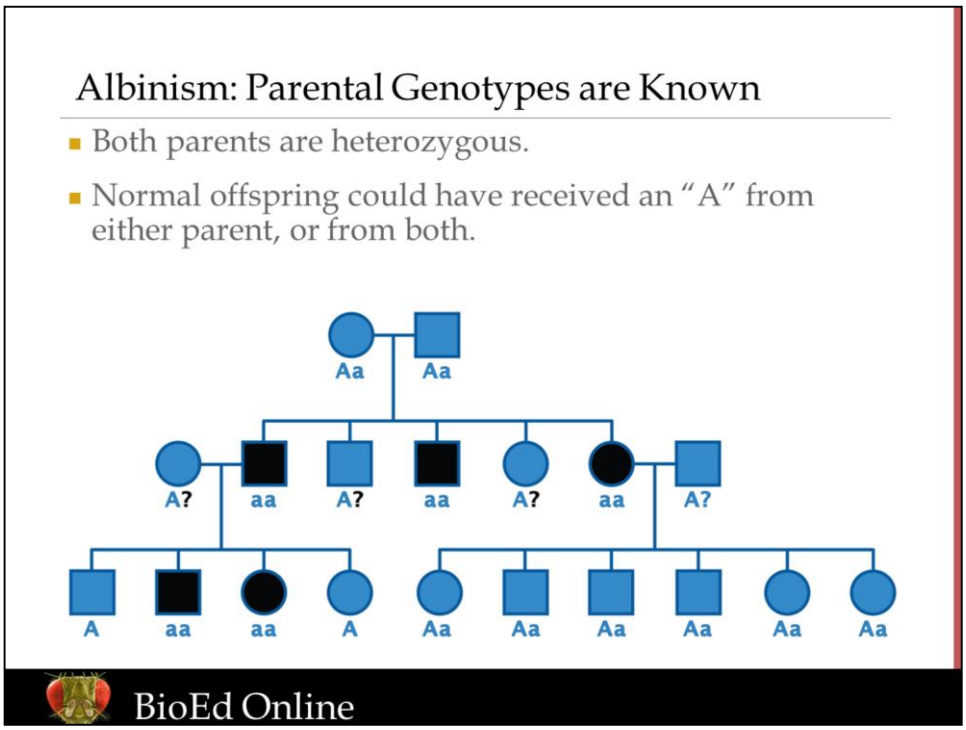
Now, we will consider more of the **parent – offspring relationships,** starting with individual #1's family. We already know that individual #1 is a homozygote for "a" because she expresses albinism. We also already have determined that her offspring must have at least one "A" because they all are normal. Thus, we can conclude that the offspring must have received their normal allele from their father, because the mother can contribute only an "a." All offspring in this family are heterozygotes. We do not have enough information to determine, for sure, whether the father (individual #2) is a heterozygote or is homozygous for the normal allele. If we consider that albinism is a rare genetic trait, however, we could fairly safely guess that the father is homozygous for the normal allele because we expect heterozygotes to be rare in the population. Still, we cannot rule out that the father is carrying the "a" allele.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Parental Genotypes are Known

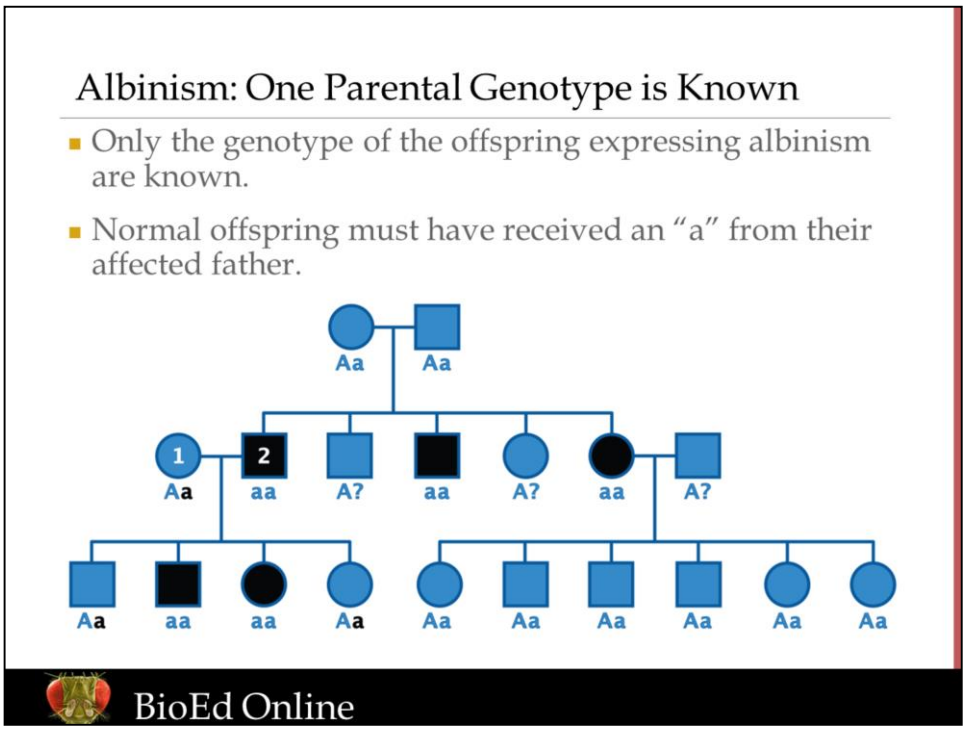
The genotype of parents in the first generation is known. In this case, we cannot determine whether the normal offspring are heterozygotes or are homozygous for the "A" allele. We know they must have at least one "A," but we cannot tell which parent gave them the "A" or if they received an "A" allele from both parents.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



One Parental Genotype Known

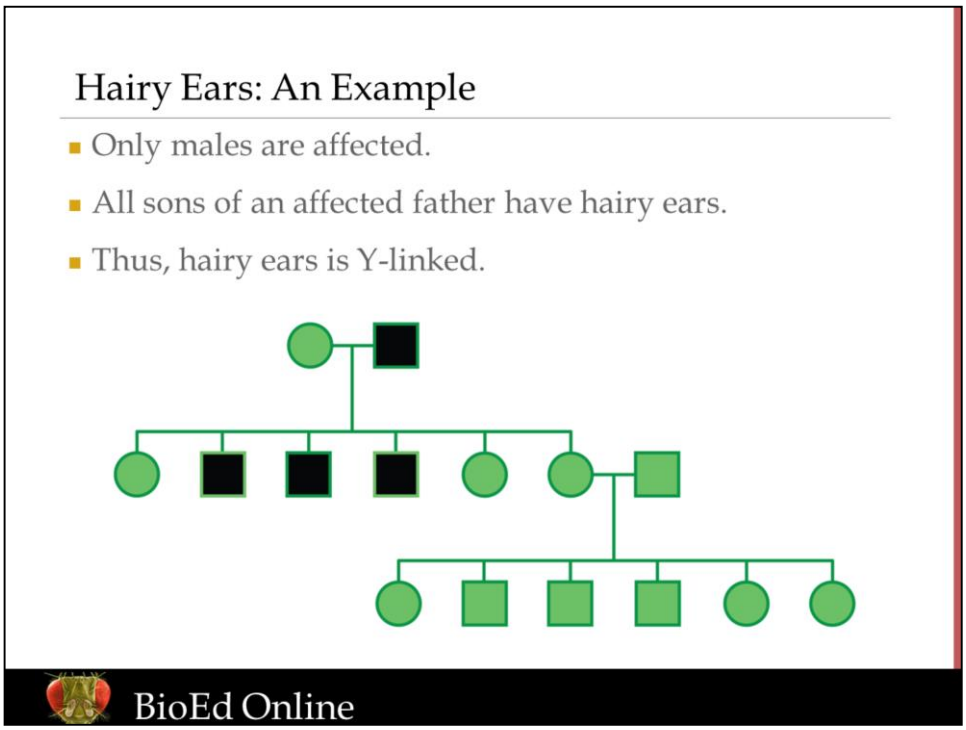
For the offspring genotypes from a mating between #1 and #2, we know at least **one parental genotype**. Even though we are unsure of the mother's genotype, we know that the affected father must have passed on an "a" allele. Thus, the normal offspring must be heterozygotes.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hairy Ears

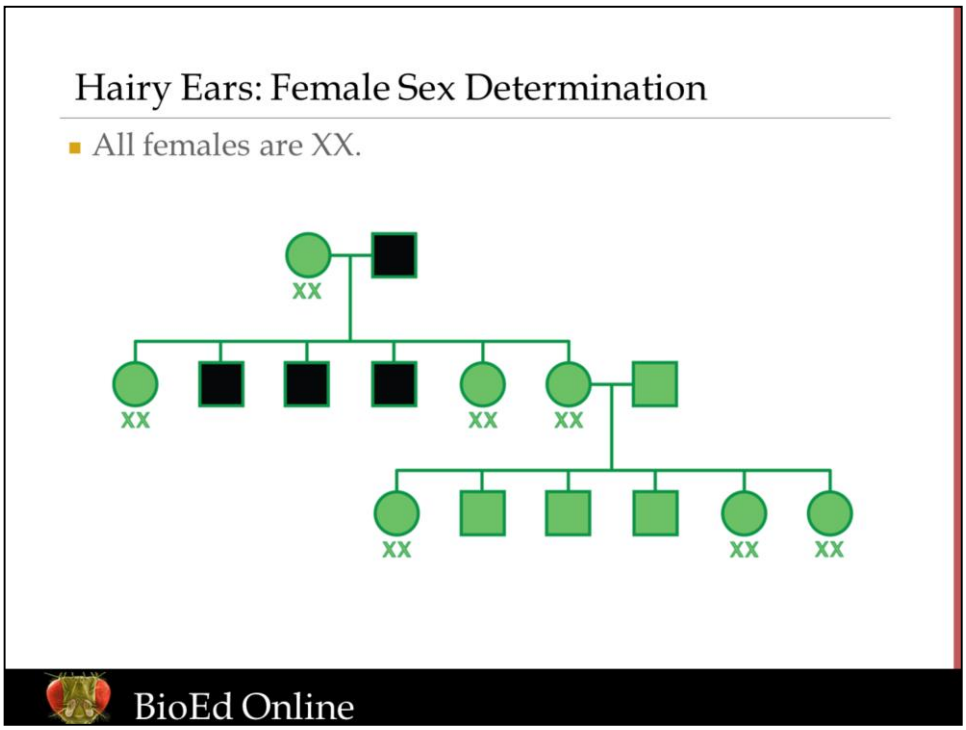
Hairy ears is a rare condition with a simple genetic basis. Only males express the trait. Moreover, all sons have the same phenotype as their fathers, whether expressing hairy ears or not. Thus, we can conclude that the gene for hairy ears is on the Y-chromosome.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hairy Ears: Female Sex Determination

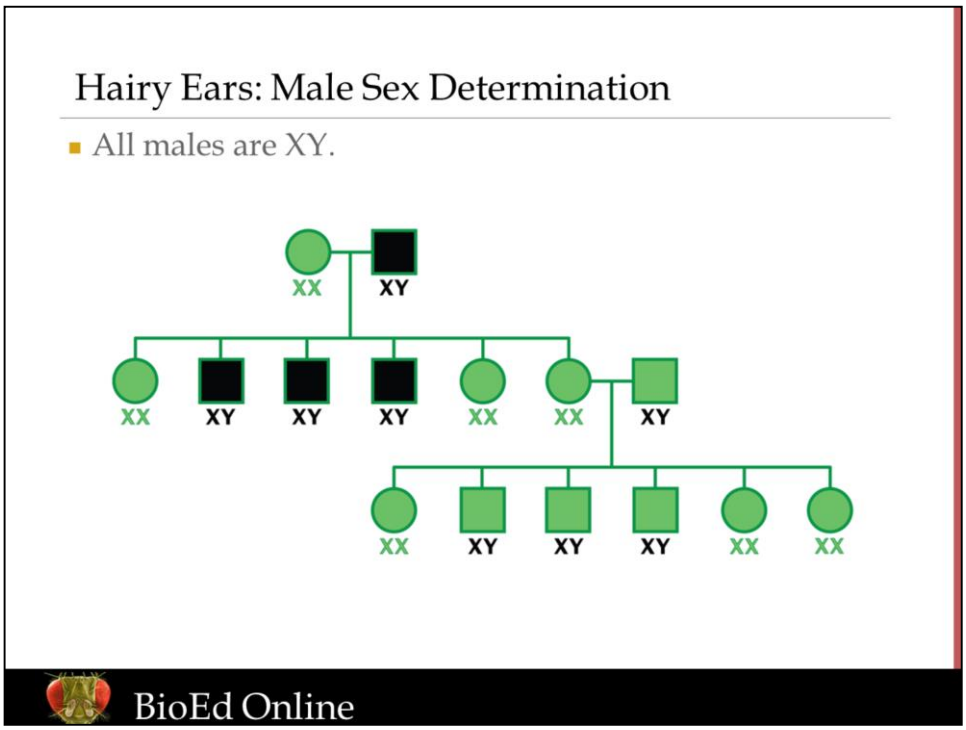
In considering the **expression of the sex chromosomes**, all females must be XX.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hairy Ears: Male Sex Determination

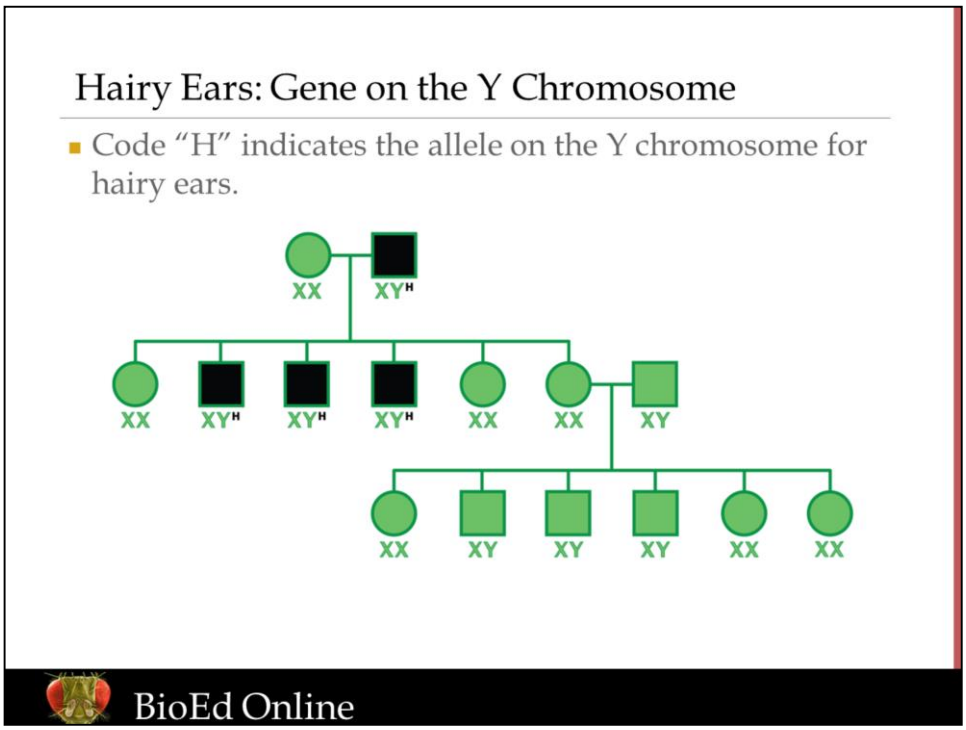
Under the human **sex determination** system, all males are XY.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hairy Ears: Gene on the Y Chromosome

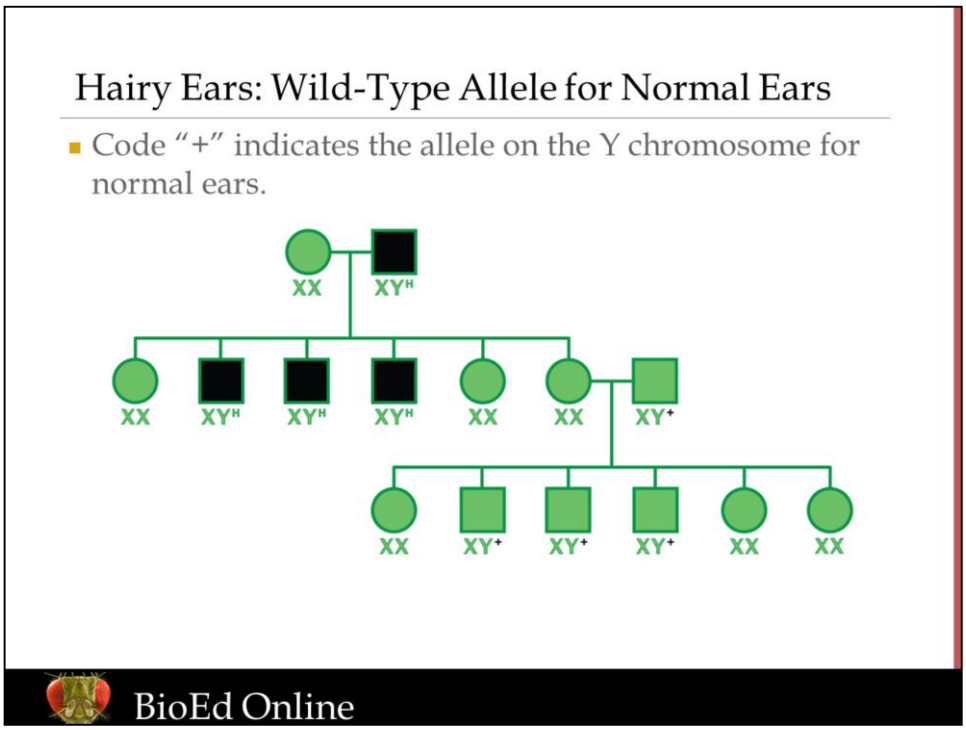
Here, we denote "H" for the **hairy ear gene on the Y chromosome.**

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Wild-Type Allele for Normal Ears

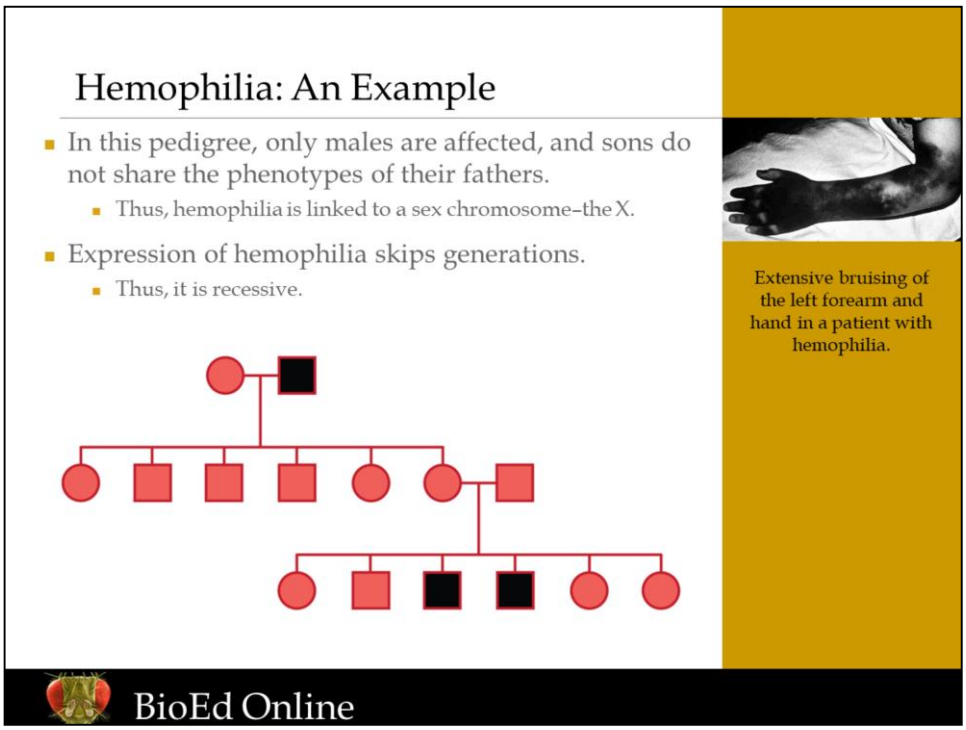
It is customary to use a "+" to denote wild-type, or normal, alleles. Thus, "+" will indicate the wild-type allele on the Y chromosome for normal ears. The daughters do not need to be genotyped because they do not have Y chromosomes.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hemophilia

Hemophilia is a condition of excessive bleeding caused by missing clotting factors in the blood. Hemophiliacs are prone to bruising, as illustrated in the photo here, and to other, potentially fatal, risk factors. In this pedigree, there is a trend for only males to express the trait strongly suggesting the role of sex chromosomes. However, the sons do not share the phenotypes of their fathers, so the Y chromosome is not a likely candidate. Thus, we can conclude that the gene for hemophilia is on the X chromosome.

Since the trait skips generations, we can assume that an allele for hemophilia is recessive to an allele for normal blood clotting factors. Although rare, a female can be afflicted if she inherits an allele for hemophilia on both X chromosomes.

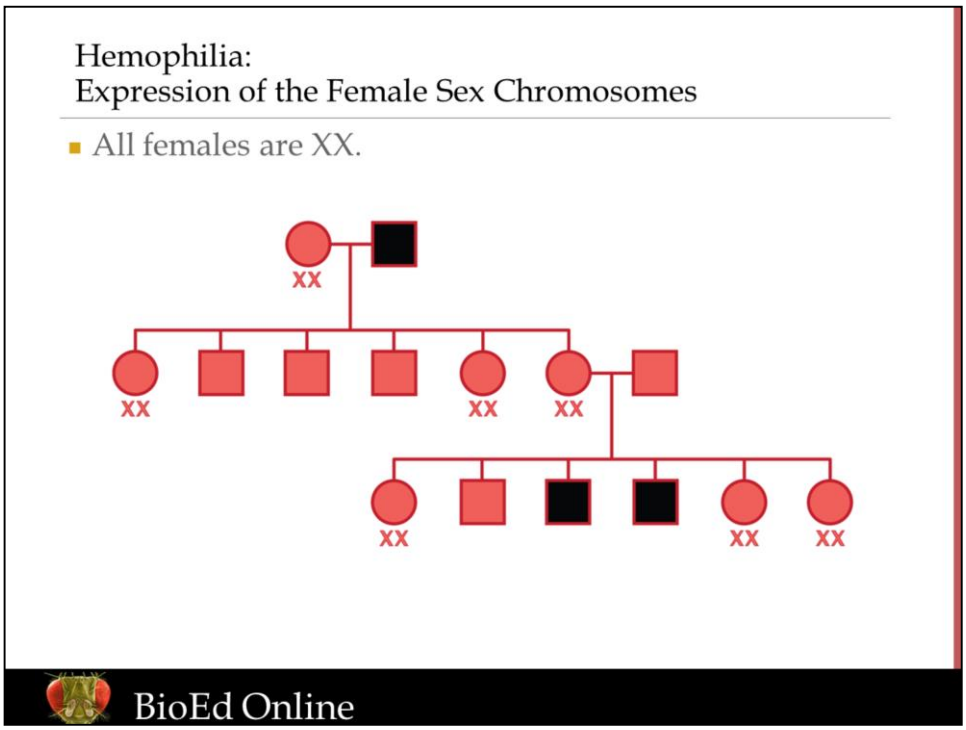
Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.

Hemophilia A. Retrieved 08-10-2006 from http://medgen.genetics.utah.edu/index.html



Expression of Sex Chromosomes

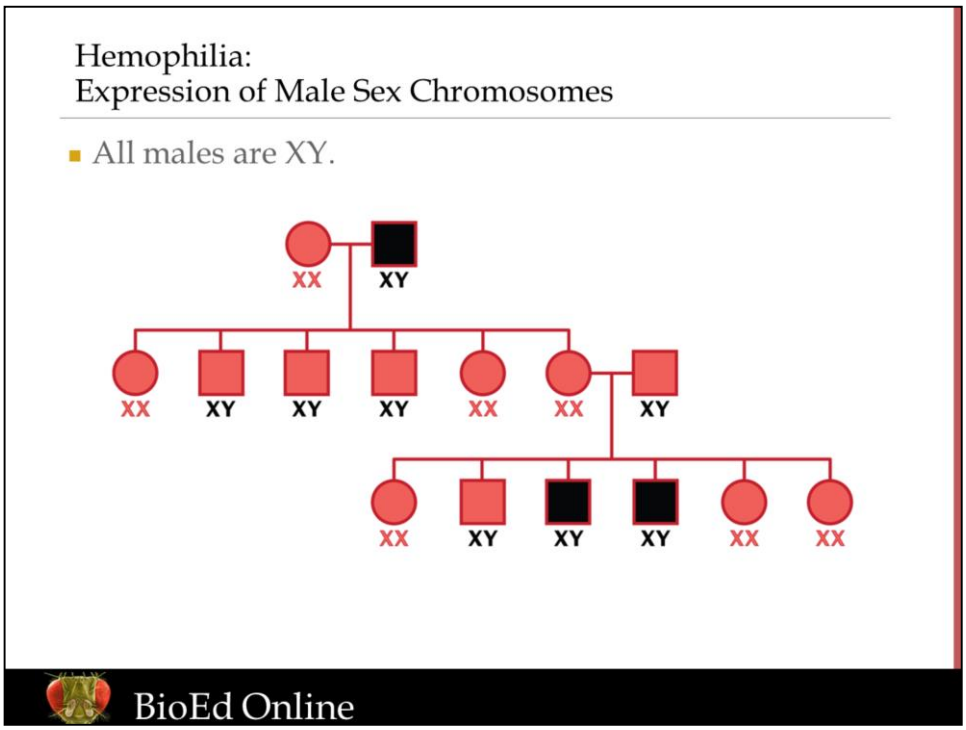
In human **expression of the sex chromosomes**, all females must be XX.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hemophilia: Male Sex Chromosomes

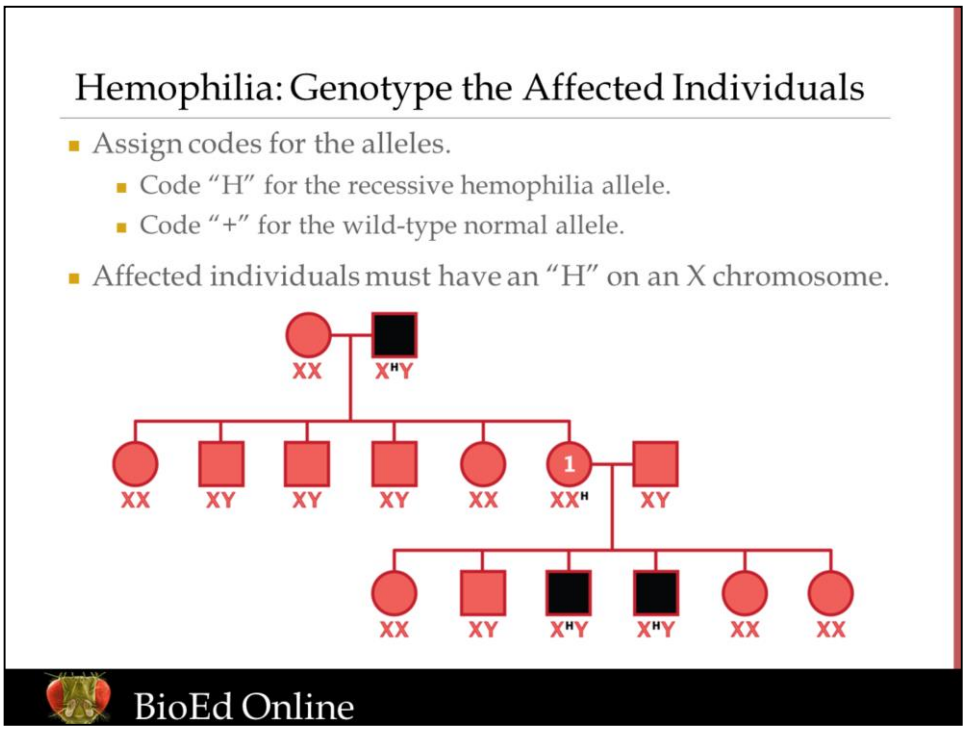
Under the human **sex determination** system, all males are XY.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hemophilia: Genotype the Affected Individuals

The first step in working out the pedigree of a recessive trait is to **genotype the affected individuals**. Here, we are using a coding system and adding a "tag" of "H" for the recessive hemophilia allele and "+" for the wild-type allele for normal blood clotting factors.

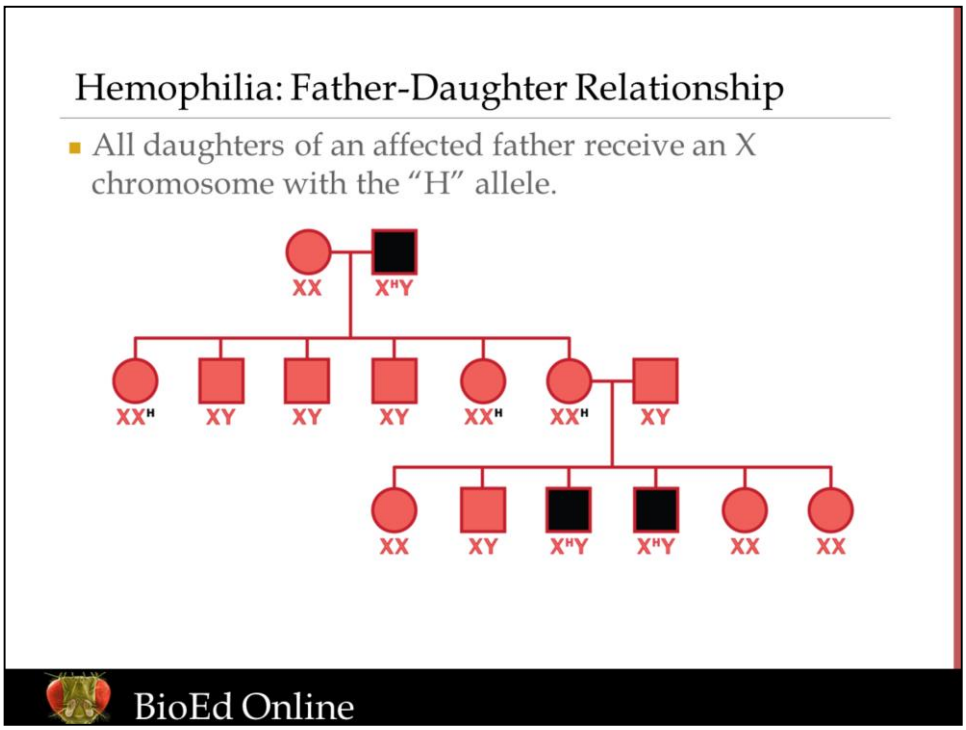
We know that affected males must have the "H" allele on the X chromosome they inherited from their mothers because they had to receive a Y chromosome from their fathers. Thus, we also know that the mother (see individual #1) of an affected son must have the "H" allele on one of her X chromosomes.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hemophilia: Father – Daughter Relationship

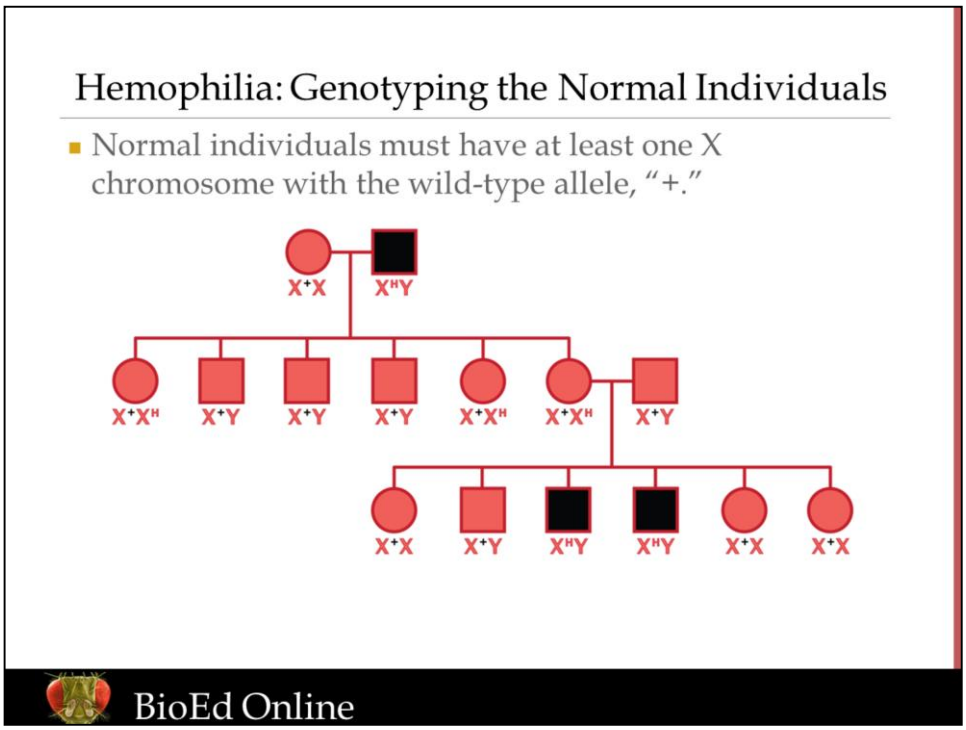
Because of the **father-daughter relationship**, all daughters of a hemophiliac father must receive an X chromosome that carries the disease. When the father passes on his Y sex chromosome, he produces a son.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Hemophilia: Genotyping the Normal Individuals

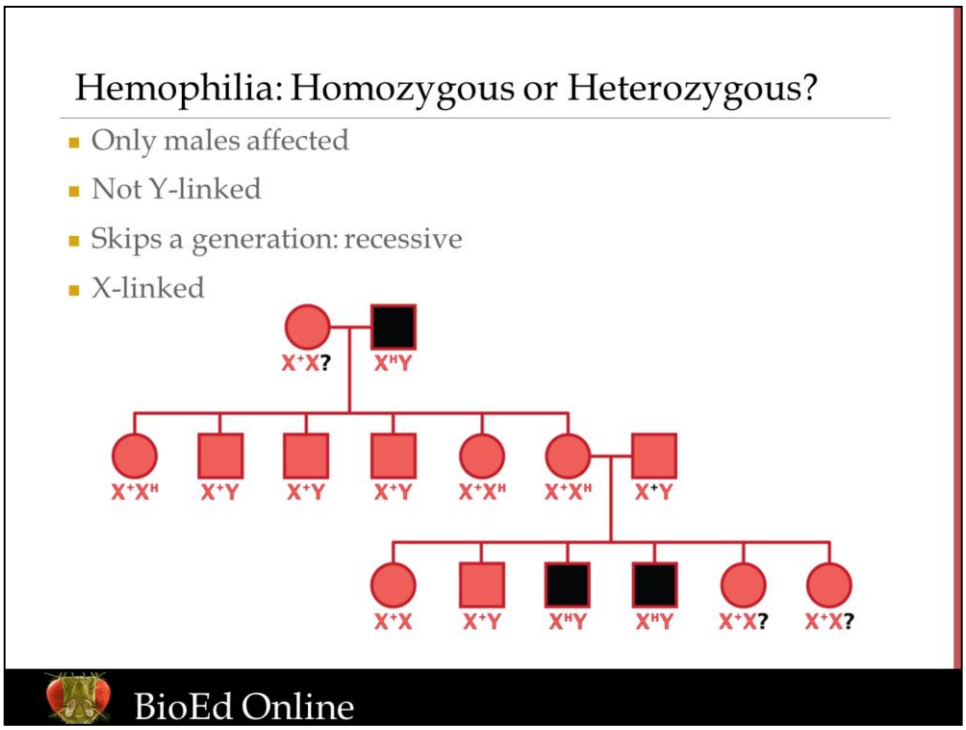
G**enotyping normal individuals** is straightforward, since every normal individual must have at least one X chromosome with the wild-type normal allele tagged, "+."

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

Young, M. (2005). *Pedigree chart.* Houston, TX: Baylor College of Medicine, Center For Educational Outreach.



Homozygous or Heterozygous?

We do not have enough information to tell if the remaining normal females are **homozygous or heterozygous**. The mother in the first generation may carry the hemophilia allele on one of her X chromosomes, and may have "gotten lucky" by transmitting only wild-type alleles to her daughters. If she were a heterozygote, you would expect half of her daughters to have hemophilia, since they all receive a hemophilia allele from their father. Since hemophilia is a rare disease, heterozygotes carrying the disease should be rare in the population. Therefore, it is likely that the mother is homozygous for the wild-type allele, but we cannot know for sure.

We know the daughters in the last generation must have at least one wild-type allele, which they could have gotten from either parent. Thus, we do not know if daughters received the father's normal allele and the mother's disease allele, or if they are homozygous for the wild-type allele.

Reference

Campbell, N. E. & Reece, J. B. (2002). *Biology* (6th ed.). San Francisco: Benjamin Cummings.

Image Reference

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