Patterns in Pedigrees 66

2
40- to 50-minute sessions

ACTIVITY OVERVIEW

Students investigate the behavior of genes for human traits. Pedigrees are introduced as another way to study genes. They are then used to analyze the patterns of transmission for recessive and dominant human traits.

Phenylketonuria (PKU), which is relatively easy to test for and treat before serious symptoms develop, is an example of a recessive human condition. Polydactyly (extra digits) is an example of a dominant trait that is surprising to students. Students also investigate and solve problems on the inheritance of ABO blood groups. Both Punnett squares and pedigrees are used as tools to analyze the genetic determination of blood type.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Students identify questions that can be answered through scientific investigations. (INQUIRY: 1)
2. Students use mathematical tools, such as Punnett squares, in all aspects of scientific inquiry (INQUIRY: 1)
3. Different kinds of questions suggest different kinds of scientific investigations. (INQUIRY: 2)
4. Genes contain hereditary information. (LIFE SCIENCE: 2)
5. The characteristics of an organism can be described in terms of a combination of traits. (LIFE SCIENCE: 2)

KEY VOCABULARY

allele

carrier

co-dominance

heterozygous

homozygous

incomplete dominance

pedigree

trait

MATERIALS AND ADVANCE PREPARATION

For the teacher

- 1 Transparency 66.1, "PKU and Polydactyly Pedigrees"
- 1 copy each of Transparencies 66.2a and b, "Three Kinds of Human Pedigrees"
- * 1 overhead projector
- * overhead transparency pens
- 1 Scoring Guide: ANALYZING DATA (AD)

For each student

- 1 copy each of Student Sheets 66.1a, b, and c, "Pedigree Puzzles"
- 1 Scoring Guide: ANALYZING DATA (AD) (optional)

**Not supplied in kit*

Masters for Scoring Guides are in Teacher Resources III: Assessment.

TEACHING SUMMARY

Getting Started

1. Introduce the use of pedigrees to study inheritance in humans.

Doing the Activity

2. Students investigate pedigrees for recessive traits through guided reading and problem-solving.
3. Students analyze a pedigree of a dominant trait (polydactyly).
4. Students learn about co-dominant inheritance in the ABO blood groups.

Follow-Up

5. (AD ASSESSMENT) Review the use of pedigrees vs. breeding, and allow students to practice problem-solving.

BACKGROUND INFORMATION

Pedigrees

The term *pedigree* is used by breeders to indicate the quality or type of genetic background that a particular animal has. In using pedigrees, or family histories of traits, to study human conditions, no value judgments should be made.

A deceased individual is indicated in a pedigree by a slash through the icon. Pedigrees involving divorces, remarriages, and adoptions are more difficult to notate, as well as to analyze. Even in seemingly straightforward cases, conclusions must be drawn carefully, whether because of the polygenic (multiple gene) nature of many traits, effects

of the environment on development (see the Teaching Suggestions in Activity 64, "Nature and Nurture," in this Teacher's Guide, for information on twin studies), or the possibility of uncovering mistaken paternity. Pedigrees are also useful for analyzing sex-linkage (traits for which the gene is found on the X or Y chromosome), but material at this depth is best left for high school biology.

Note to users of GenScope: This computer-based application uses a shaded icon for recessive traits; in human pedigree analysis, the trait of interest (usually a "condition") is indicated with a shaded icon, whether it happens to be recessive or dominant.

Human Hereditary Diseases

The background to Activity 56, "Joe's Dilemma," contains information about several specific human genetic conditions that have been studied using pedigrees. This activity focuses on the use of pedigrees to study the inheritance of genetic conditions in general. Students will discover over the course of this activity and the next one that while all genetic disorders are fairly rare, some are recessive (such as PKU, sickle cell disease, and cystic fibrosis) and some are dominant (such as polydactyly, the Marfan syndrome, and Huntington's disease). Recessive conditions can be carried in a family for many generations without anyone being aware of them until a carrier has children with another carrier. In other words, they can skip one or more generations, just as the recessive pea plant traits identified by Mendel do (also see Figure 1 on page D-66 in the Student Book for critter tail color).

This activity uses three human conditions as examples: phenylketonuria (PKU), polydactyly, and the ABO blood groups. Polydactyly is an example of a relatively straightforward human trait that is not associated with any negative health effects. PKU is a genetic condition whose developmental effects can be prevented quite successfully with appropriate dietary restrictions (PKU is an enzyme deficiency that results in the accumulation of phenylalanine, which affects brain development). Interestingly, if a woman with PKU becomes pregnant, she must return to eating a restricted diet in order to prevent undesirable effects on the fetus, even if the fetus is only a carrier for PKU.

We have avoided using serious conditions such as sickle cell anemia, cystic fibrosis, Tay-Sachs disease, and Huntington's disease as examples of human hereditary diseases in this unit for two reasons. First, they present a picture of genetics as relating only to very serious and emotionally difficult subjects that may be more appropriate for older students. Second, with the exception of Huntington's disease, these conditions are of concern primarily to specific ethnic groups. Therefore, we have not made them central to the unit. Informational weblinks are provided on the SALI page of the SEPUP website. (See Extension in Activity 56, "Joe's Dilemma".)

Human ABO Blood Groups

The ABO blood types are familiar to students and useful for problem-solving practice, and are also essential in Activity 68, "Searching for the Lost Children." The human AB blood type is an example of co-dominance. An individual with type AB blood has both

"A" and "B" antigens on the surfaces of the red blood cells. His or her body therefore does not make antibodies to either the A antigen or the B antigen.

Type A blood and type B blood are thus co-dominant traits, and type O blood is recessive to both of them. Type A people can be either AA or AO in their allele combinations; type B people can be either BB or BO. Note that the use of the symbols A, B, and O for the *alleles* that determine the A, B, O, and AB blood type *traits*, though convenient, can be confusing for students.

The A and B alleles cause two different antigens to be expressed on the surface of red blood cells. The O allele does not lead to the production of either antigen.

Blood Type	Allele Combinations	Antigen(s) on surface	Can donate to	Can receive from
O	OO	none	all	O only
A	AA or AO	A	A or AB	A or O
B	BB or BO	B	B or AB	B or O
AB	AB	A and B	AB only	all

"Blending Inheritance"

The concept of "blending inheritance" in animal and plant breeding is that traits in an offspring are a "blend" of the traits of its parents. It is a misleading term when applied to incomplete dominance, because it suggests the blending of traits themselves, rather than the blending of effects of two different alleles inside the cells of an organism.

REFERENCES

Griffiths, A. J. F., et al. *An Introduction to Genetic Analysis.* New York: W. H. Freeman and Company, 1993.

TEACHING SUGGESTIONS

■ GETTING STARTED

1. Introduce the use of pedigrees to study inheritance in humans.

Ask, ***How is human genetics studied?*** The critter-breeding simulations and seed germinations were used to understand the basics of genetics, especially dominance and recessiveness (discovered by Mendel in his work with peas). However, students should realize that other approaches are required for studying human inheritance. Some may suggest, however, that information is available from humans, in the form of data on traits from families that already exist. Explain that students will explore the use of pedigrees—family histories of traits—to study human genetic conditions.

■ **Teacher's Note:** Mutations are not directly addressed in the context of pedigree analysis until Activity 67, "What Would You Do?" In the current activity, students are implicitly asked to assume that all alleles are inherited unchanged. Be prepared for students to remember from Activity 63, "Show Me the Genes!" that mutations sometimes occur during the formation of sex cells (their occurrence makes interpreting pedigrees more difficult).

Have students look at "A Partial Pedigree of Hemophilia in the Royal Families of Europe," in the activity introduction in the Student Book. Draw their attention to how it is organized, and then have them look at the other pedigrees on the succeeding pages. Within their groups of four, have students develop rules for reading or constructing a pedigree and write them in their notebooks.

Rules may include the following:

1. Pedigrees always have a title.
2. Pedigrees always have a key.
3. Females are represented by circles.
4. Males are represented by squares.
5. The affected individual is represented by a another color.
6. Members of the same generation are at the same horizontal level.
7. Parents of offspring are connected with a horizontal line.
8. Offspring are connected to their parents with a vertical line.

■ **Teacher's Note:** The pedigree in the Student Book is a *partial* pedigree. Some spouses and children are omitted in this version, which emphasizes affected individuals and other well-known members of this large royal family.

Once groups have developed some rules, hold a class discussion to summarize the rules. Post these on chart paper, and have students add these and any additional rules the group or class develops over the course of the activity to their notebooks. As the unit progresses students will follow these rules in reading and constructing pedigrees.

■ **Teacher's Note:** Students often have mistaken ideas about the term carrier in the context of genetic conditions. Like a carrier of an infectious disease, a carrier of a genetic disease does not display symptoms, but is able to transmit the disease. However, a carrier of a genetic disease can only transmit it to its offspring via hereditary mechanisms, while a carrier of an infectious disease can transmit it to anyone with whom they have contact in a way that allows the disease to be transmitted. A carrier of a genetic condition has an allele for a recessive trait. Another mistaken idea that students often have is that dominant traits always make up the majority of a population. Blood types are an example of dominant traits NOT making up the majority of the population. The most common blood type is type O, and yet it is recessive to types A, B and AB.

■ DOING THE ACTIVITY

2. Students investigate pedigrees for recessive traits through guided reading and problem-solving.

Hand out Student Sheets 66.1a, b and c, "Pedigree Puzzles." Student Sheet 66.1a provides images of the pedigrees presented in the reading. Point out to students that the Stopping to Think questions ask them to use the Student Sheet as a worksheet for labeling individuals with allele combinations.

The reading (and Stopping to Think questions) can be assigned as homework, but since some students find pedigrees very challenging, it is a good idea to have students finish at least the first Stopping to Think question in class. It is also helpful for students to be able to discuss the reading and check their work on the Stopping to Think questions in groups of two or four.

Use Stopping to Think 1 as an opportunity to review the critter scenario in the context of pedigree analysis. As necessary, walk small groups of students through the labeling of allele combinations until all have confirmed that the orange tail trait is recessive: Skye is TT, Poppy is tt; Ocean and Lucy, like all Generation Two critters, are Tt; the orange-tailed offspring of Ocean and Lucy are tt. The blue-tailed Generation Three offspring could be either TT or Tt (you may have students label these as "T_"). Note that pencil is preferable to pen, at least for students who do not feel comfortable crossing out their work.

The next section of the reading asks students to use a pedigree to figure out whether a certain human condition (phenylketonuria, or PKU) is dominant or recessive. Emphasize that PKU is an example of a genetic disorder that is quite treatable if discovered early; it also highlights the importance of the development of traits, since the special diet that prevents brain damage needs to be followed only during the first ten years of life. Even students who have never heard of PKU may have noticed the warnings often seen on packaged food: "Attention phenylketonurics: contains phenylalanine."

Based upon evidence from numerous pedigrees similar to "Family with PKU," scientists have concluded that PKU is recessive and appears only if both parents are carriers and both transfer a disease allele to the same child. Students may respond to Stopping to Think 2 by noticing how similar the PKU pedigree is to the Pedigree critter tail color, since the orange-tail trait also skips a generation (some students may have already heard this expression). However, encourage all students to methodically assign allele combinations to the individuals on the pedigree, using Student Sheet 66.1. Use Transparency 66.1, "PKU and Polydactyly Pedigrees," as necessary to lead class discussion. Be sure to label allele combinations one at a time using an overhead transparency pen, while having students describe their reasoning process.

An explanation might be: "First, assume that the trait is dominant. The grandmother could be heterozygous (Pp) and give the normal allele to both her son (pp) and daughter (pp). But then her son has seven kids with a woman who also doesn't have it, and two of their children have PKU (Pp). Where'd those two kids get the allele for PKU? So, it must be recessive, since so many PKU pedigrees look like this one. Now, say that the grandmother has it (pp), and both her kids are heterozygous for it (Pp). (The grandfather could be PP or Pp.) Her son happens to have kids with a woman who is also heterozygous (Pp), and two of their seven kids have PKU (pp). For the other five kids, I don't know if they're Pp or PP, so I'll label them (P_)."

■ **Teacher's Note:** When discussing rare genetic traits, it is usual to refer to the more common allele as the "normal" allele. Stress that in this context, *normal* means "common" and does not suggest that people with genetic conditions are abnormal in a pejorative sense.

After being introduced to the concept of a genetic **carrier** of a recessive trait (a heterozygous individual), students answer Stopping to Think 3. If only one parent is a carrier, a child cannot receive a recessive allele from the other parent, except in rare cases of random mutation occurring at sex cell formation. (The other parent does not have the recessive allele to give to an offspring.) However, a child of a single carrier may also be a carrier (there is a 50% chance for each child).

Note that because PKU is relatively rare, the condition usually is found in children of parents who have no idea they are carriers. Students may also notice that Ocean and Lucy, as siblings, both inherited a recessive orange-tail allele from the same individual; in human lineages, the two carrier parents are generally from two different families that have never or rarely included an individual showing the recessive trait.

3. Students analyze a pedigree of a dominant trait (polydactyly).

Students often wrongly assume that because genetic diseases and conditions are not common, they are all recessive. The next section of the reading explores the condition polydactyly. As you circulate, ask, ***Do you expect polydactyly to be recessive or dominant?*** As students assign allele combinations to the "Family with Polydactyly" Pedigree using Student Sheet 66.1a, they will discover the condition is dominant.

As was done for PKU, talk through Stopping to Think 4 step-by-step as needed, using Transparency 66.1, "PKU and Polydactyly Pedigrees." Again, be sure to label allele combinations one at a time, while having students describe their reasoning process.

An explanation might be: "Assume the trait is recessive, like PKU. Then both grandparents are homozygous (pp) and their children are also. But they have a son without polydactyly! So maybe polydactyly is dominant—it doesn't skip a generation anyway. If it's dominant, then the grandparents are either homozygous (PP) or heterozygous (Pp); but they have a son who must be homozygous recessive (pp) because he doesn't have it, so they both must be heterozygous (Pp) so he can get a normal, recessive allele from both of them. The daughter with polydactyly has no kids, so she could be heterozygous or homozygous . . . but the son has children without polydactyly, so he must be heterozygous (Pp) and his wife is homozygous (pp)."

This is a good time to ask, ***Would we always know, for a dominant condition, whether individuals with children are homozygous or heterozygous?*** Unlike in large breeding experiments, sample size is limited in human pedigree analysis; in this case, there happened to be enough children to draw this conclusion. Similarly, predicted and actual ratios cannot be compared using pedigrees, since sample size is almost inevitably too small. However, the probability of a child inheriting a condition can be estimated using pedigrees; this is a common aspect of genetic counseling.

■ **Teacher's Note:** This is a good point at which to end the first class period.

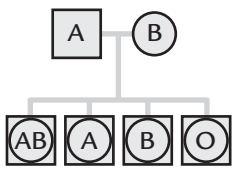
4. Students learn about co-dominant inheritance in the ABO blood groups.

The final section of the activity explores the inheritance of ABO blood groups, knowledge of which is essential for students to complete Activity 68, "Searching for the Lost Children." If you used the *Issues and Life Science* unit "Cell Biology and Disease," remind students of what they learned about blood transfusions and blood incompatibility in Activity 46, "Disease Fighters." Recipients cannot receive transfusions of blood that contain blood cells they recognize as foreign, because they will mount an immune reaction against the transfused blood. (A similar immune response, but different antigens on the surfaces of cells, leads to rejection of organs in organ transplants.)

Direct students' attention to Table 1 in the Student Book and reproduced on Student Sheet 66.1b. This table summarizes data from many, many pedigrees. For example, line 1 tells us that if both parents have Type O blood, then the only blood type observed in their offspring is Type O. Line 2 tells us that when Type A and Type O individuals have children, both Type A and Type O children are observed.

In the process of figuring out what allele combinations are possible for each blood type, students infer the rules of inheritance for this characteristic: blood types A and B are co-dominant, and O is recessive to both of them. For example, type O shows a recessive pattern: two type O parents can have only a Type O child. Both Type A and Type B parents can have a Type O child, which means Type A and Type B individuals can both be heterozygous with an O allele. Type A and Type B are co-dominant: when present together, both alleles/blood types are seen—neither is masked by the other.

Encourage students to explore these rules of inheritance using the workspace on the Student Sheet. For example, they might sketch a pedigree representing the last line of Table 1:



Students would then have to label the Type A parent as "AO" and the Type B parent as "BO" in order to explain how they could have a Type O child.

FOLLOW–UP

5. (AD ASSESSMENT) Review the use of pedigrees vs. breeding, and allow students to practice problem-solving.

Ask students, ***What are the advantages and disadvantages of using pedigrees, rather than breeding studies, to gather genetic information?*** (If this proves too difficult a question for your students, guide them through it by asking them to consider factors such as time, sample size, and ethical considerations.) An advantage of pedigrees is that they use existing information, although such data generally involve small sample sizes. Students should realize that although breeding produces enough data for mathematical (statistical) analysis, it is unethical for studying humans and sometimes impractical for studying traits in large animals (which have long gestation times and require substantial resources to raise). Point out that pedigree studies are also used to study traits in animals such as livestock and pets.

Analysis Question 1 explores the use of pedigrees to deduce probable allele combinations in parents. Encourage students to re-draw the four pedigrees and label them with allele pairs to organize their thinking.

■ **Teacher's Note:** Analysis Question 1c requires probabilistic thinking, but it is not necessary to go into the details. If desired, with Parents 5 and 6, draw a parallel to the likelihood of a family with six children having six daughters. Although this is unlikely, it does happen occasionally. The probability is the product of the six probabilities involved, each of which is 1/2. Thus, the probability is (1/2) (1/2) (1/2) (1/2) (1/2) (1/2), or $(1/2)^6$, or 1/64. (Similarly, in Question 2b, the chance that all six of Jan's children would have the dominant condition if Jan were heterozygous would be $(1/2)^6 = 1/64$.)

If students have difficulty with Question 1, the following supplementary question can help to prepare them:

Two individuals who are carriers of PKU have children together.

a. What is the probability that the first child will have PKU? Use a Punnett square to explain your answer.

	P	p
P	PP	Pp
p	Pp	*pp*

The probability is 1/4.

b. Of their first four children, all have PKU. How surprising is this?

For each child, the probability of inheriting PKU is 1/4. The probability of four children in a row having PKU is very low: $(1/4)^4 = 1/256$.

In answering Analysis Questions 2, 3, and 4, students should use Student Sheet 66.1c. As necessary, use a transparency copy of the Student Sheet or Transparencies 66.2a and b, "Three Kinds of Human Pedigrees," to review the strategy of labeling individuals on a pedigree with allele combinations in order to decide whether a trait is recessive or dominant.

■ **Teacher's Note:** The first edition of the Student Book includes a misprint in the pedigree for Genetic Condition One on page D-64. The connection from Jan to her third child should be to the affected male, not the unaffected female. The correct pedigree is in the Suggested Answers to Analysis Questions and on Transparency 66.2a. The corrected student page is posted on the teacher page of the *IALS* website.

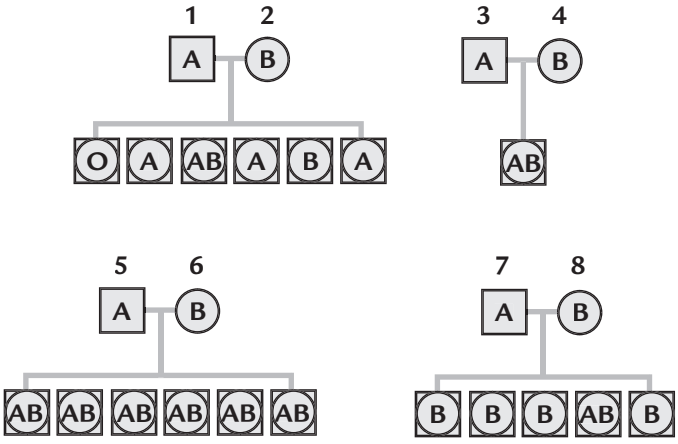
Analysis Questions 3 and 4 are opportunities for you to assess students' thinking about pedigrees and understanding of how traits are inherited through generations. Analysis Questions 3 and 4 can also be assessed with the ANALYZING DATA vari-

able. If students are struggling, you may wish to use Analysis Question 3 as a practice and Analysis Question 4 as a scored assessment. Share with students the criteria that you will use to score their answers. Note that the second page of the transparency presents the two possibilities for Question 4 (that the trait is dominant provides a more plausible explanation).

Question 5 addresses the two very different uses of the term carrier in biology. The concept of disease carrier is critical to epidemiologists and public health workers who study the spread of disease; the concept of genetic carrier is used in the study of hereditary conditions and in genetic counseling.

SUGGESTED ANSWERS TO QUESTIONS

1. *The following pedigrees represent the blood types in four unrelated families. In each case, the parents have Type A and Type B blood.*



   a. *Which of the 8 parents are definitely heterozygous for the Type O allele? Explain.*

      Parents 1 and 2 must each have an O allele, because Type O blood (OO gene combination) appears in their first child. Parent 7 must also have an O allele, since his Type B children must have inherited an O allele from him and a B allele from his wife, Parent 8. (If all the children had inherited only A alleles from him and only B alleles from the mother, they would all be AB.)

   b. *Which of the 8 parents are probably not heterozygous for the Type O allele? Explain.*

      It is very unlikely that Parents 5 and 6 are heterozygous; their children are all Type AB, indicating that none of them received an O allele. Parent 8 probably does not have an O allele, as she transmitted a B allele to all five of her children. Since Parent 3 and 4 only have 1 child, too little is known to determine whether they are likely to be heterozygous.

   c. *Can you be certain that the parents you named in response to Question b do not have a Type O allele? Explain.*

      You cannot be certain that Parents 5, 6, and 8 are homozygous. However, the probabilities that they are heterozygous for the O allele are quite low, based on the numbers of children all of whom did not receive O alleles from these parents.

2. *The pedigree shown on the next page represents a genetic condition. Use the information it provides to answer the questions below. Use Student Sheet 66.1c to try out allele combinations for related individuals.*

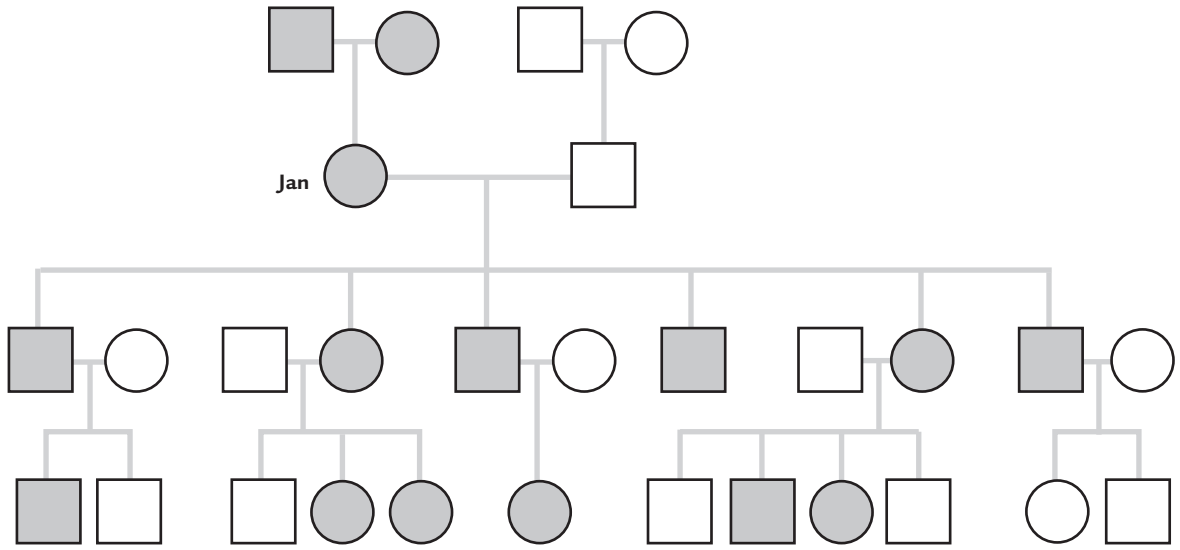
   a. *Is the condition most likely a dominant or a recessive trait? Explain your reasoning.*

      This condition does not skip any generations in this family, so it is likely that the condition is dominant.

      n Teacher's Note: It is conceivable that the condition is recessive, but in that case, Jan's partner and all of her children's partners would have to be carriers. This is unlikely unless the trait were very common in the human population, or in whatever pool from which Jan's family selects mates.

   b. *Is Jan most likely to be homozygous dominant, heterozygous, or homozygous recessive?*

      Since all six of Jan's children have inherited the condition, which her husband does not have, it is likely—but not certain—that Jan carries two copies of the allele for the trait (homozygous dominant). For this to be possible, both of Jan's parents must have the condition (they do).



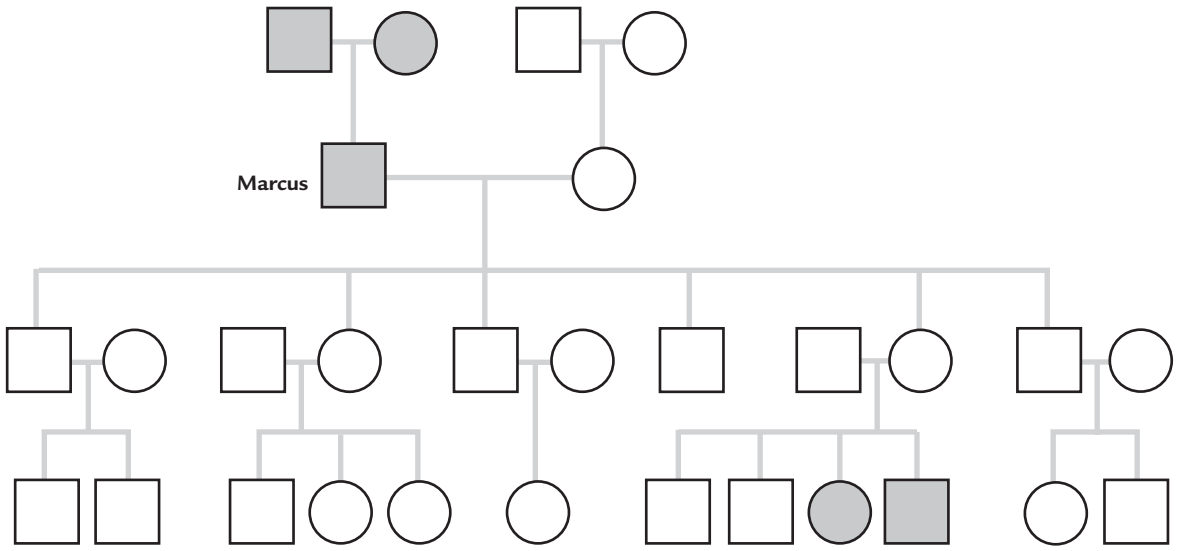
3. *(AD Assessment) The pedigree shown below represents another genetic condition.*

   a. *Is the condition most likely a dominant or a recessive trait? Explain your reasoning.*

   Level–3 Response

   his condition skips a generation, which is typical of recessive traits. If the trait were dominant, it would be seen in at least one parent of any affected individual. Since none of Marcus's children has the genetic condition, but one of them has children who do, the condition must be recessive, and all of Marcus's children are carriers. Furthermore, since Marcus's fifth child (a daughter), has affected children, her husband must also be a carrier.

   Have students note the similarity between this pedigree and the "Family with PKU," pedigree in the Student Book. Students may insist on the possibility that this condition is dominant and arises in the youngest generation from mutations during reproduction. However, two children in that family are affected, making it even less likely that the condition is dominant (two of the same mutation among four children is improbable).



b. Is Marcus most likely to be homozygous dominant, heterozygous, or homozygous recessive?

Since the condition is recessive, Marcus must be homozygous recessive, or he would not have the condition. However, all his children are heterozygous, i.e. carriers of this recessive trait.

4. *(AD ASSESSMENT) The pedigree shown below represents a third genetic condition.*

a. Is the condition most likely a dominant or a recessive trait? Explain your reasoning.

Level–3 Response

It is likely to be a dominant trait, as it does not skip any generations. It could be recessive if every partner of an affected individual happened to be a carrier (of which there are four examples in the pedigree), but this is improbable since most genetic conditions are rare.

■ **Teacher's Note:** Only Sophia's affected children pass the gene on to her grandchildren, which would be somewhat unlikely if the trait were recessive. Nevertheless, this problem provides an opportunity to see that a recessive trait can fail to skip a generation even within a sizable pedigree, as shown on Student Sheet 66.2. This trait is more plausibly dominant than the trait in Question 2, whose pedigree would require six (not four) affected individuals to have had carriers as partners.

b. Is Sophia most likely to be homozygous dominant, heterozygous, or homozygous recessive?

Because only one of Sophia's parents and some of her children have the condition, it appears that she is heterozygous.

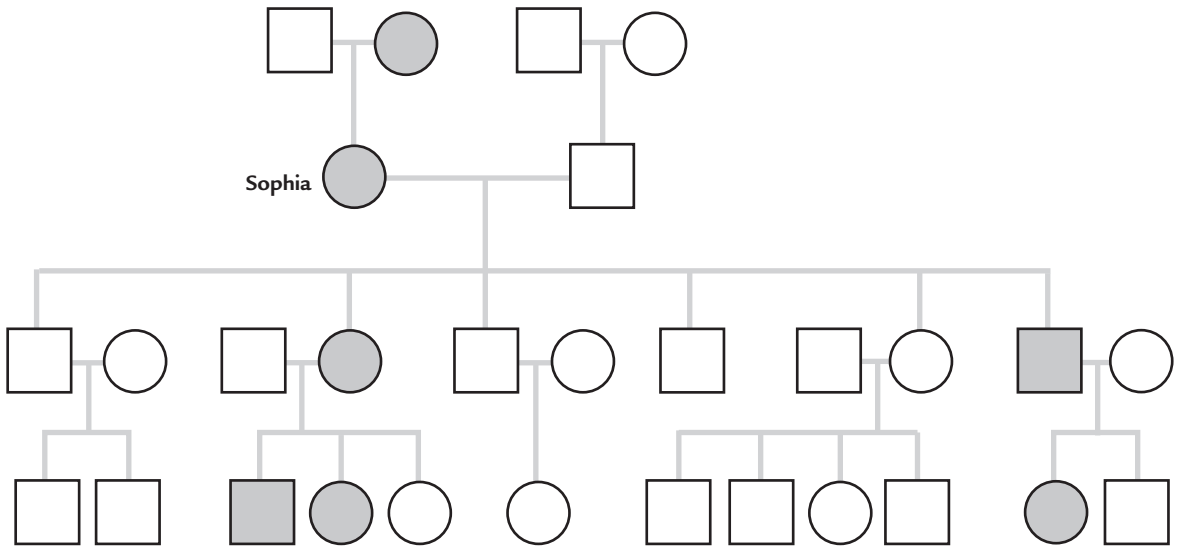
5. *The term carrier is used very differently in genetics than in the study of diseases.*

a. What is being "carried" by a genetic carrier? What is being "carried" by a disease carrier?

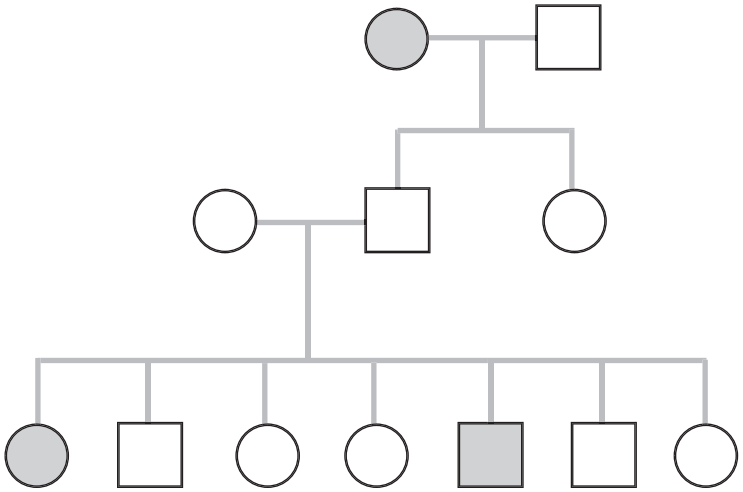
A genetic carrier carries an allele for a recessive trait (usually for a hereditary disease or condition). A disease carrier is an individual infected with a microbe that causes an infectious disease, but who does not show symptoms of that disease.

b. How does transmission occur for genetic conditions? How does transmission occur for infectious diseases?

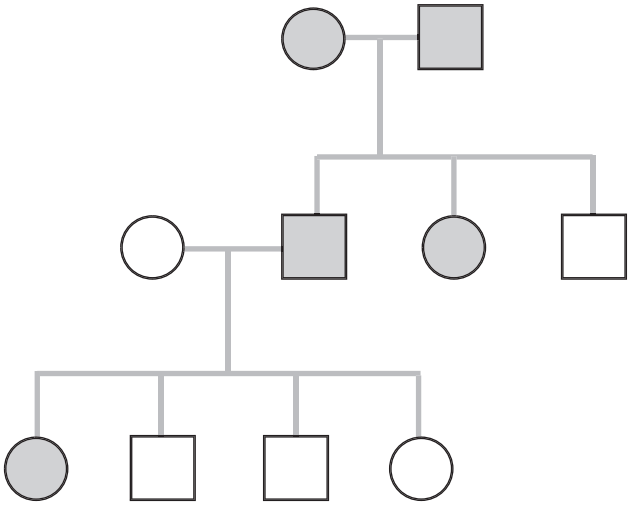
Transmission of a genetic condition occurs through reproduction. Transmission of an infectious disease occurs when a carrier (or sufferer) transmits a microbe to another individual.



PKU and Polydactyly Pedigrees

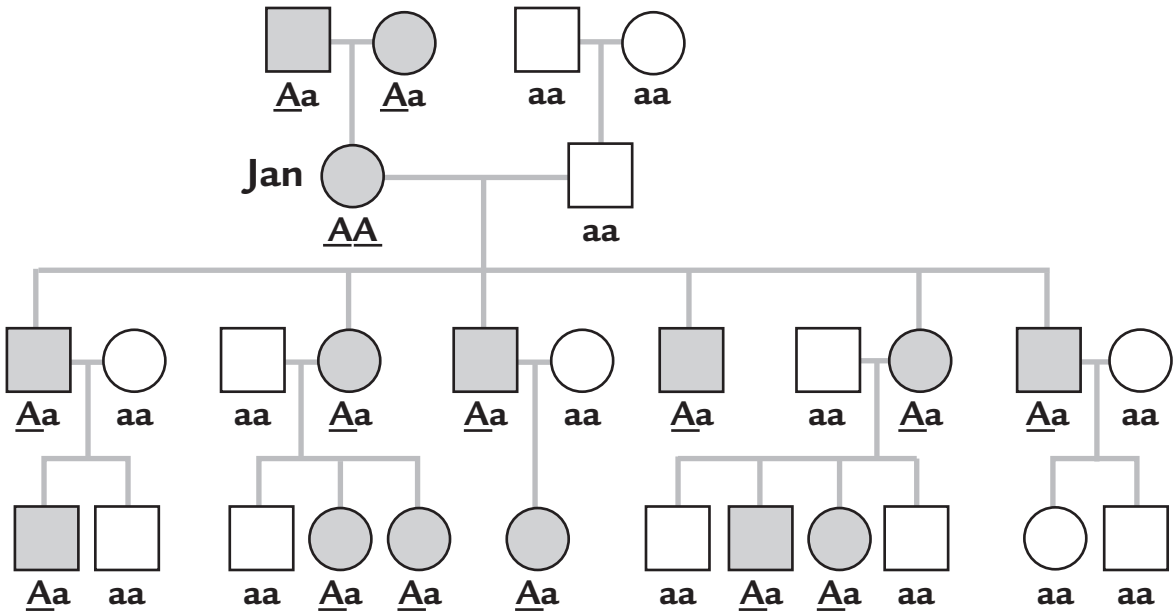


Family with PKU

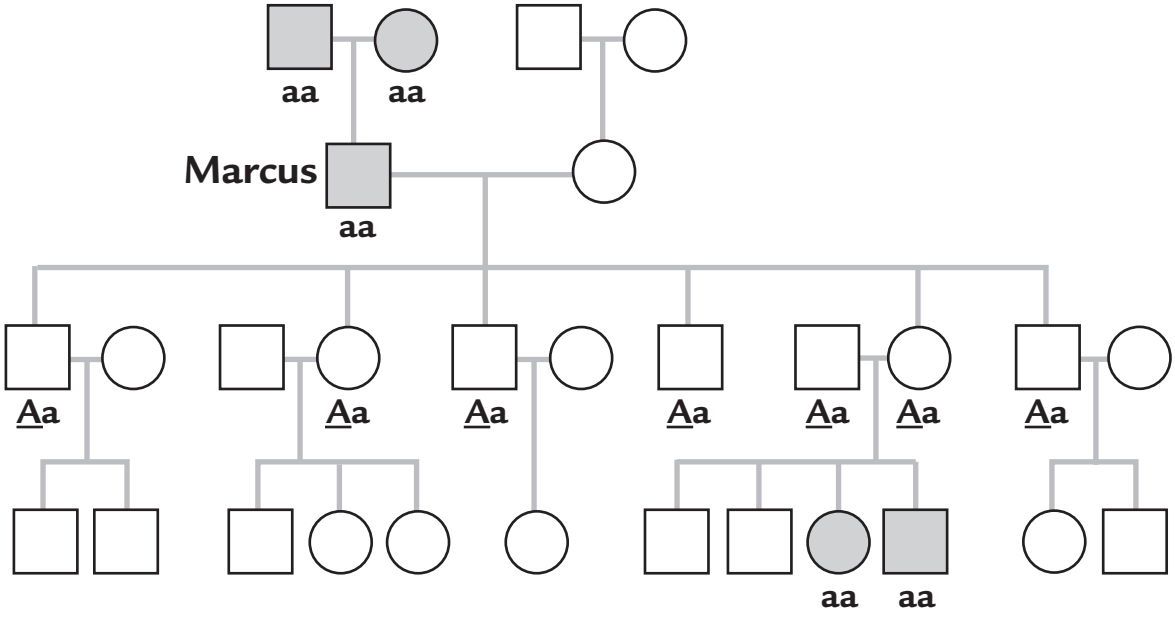


Family with Polydactyly

Three Kinds of Human Pedigrees

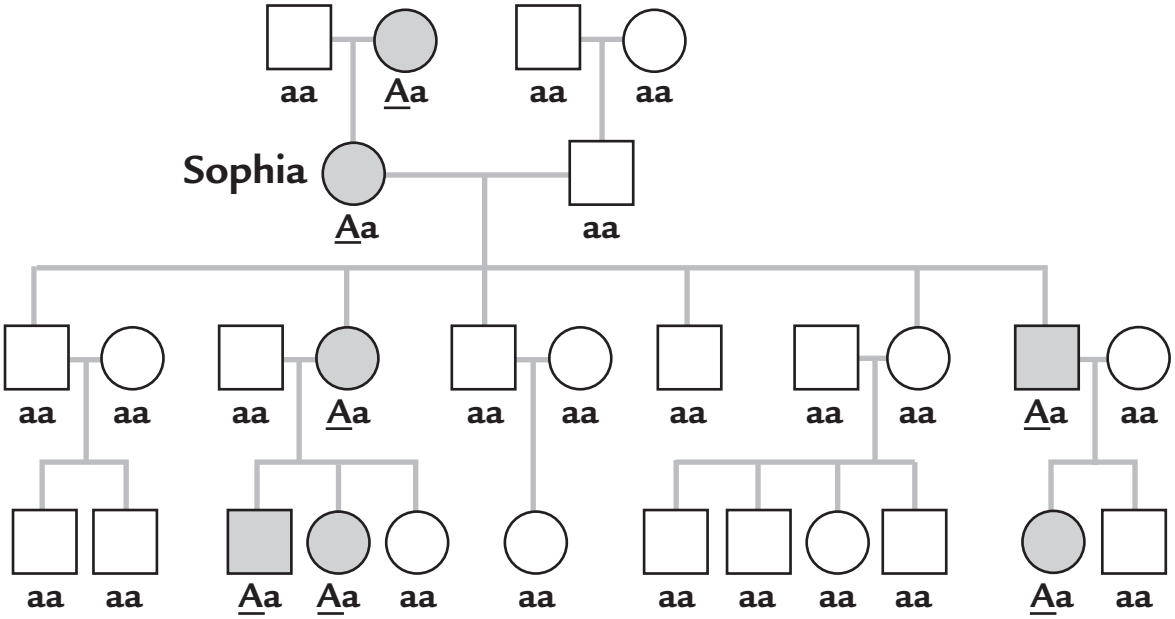


Question 2: A dominant trait

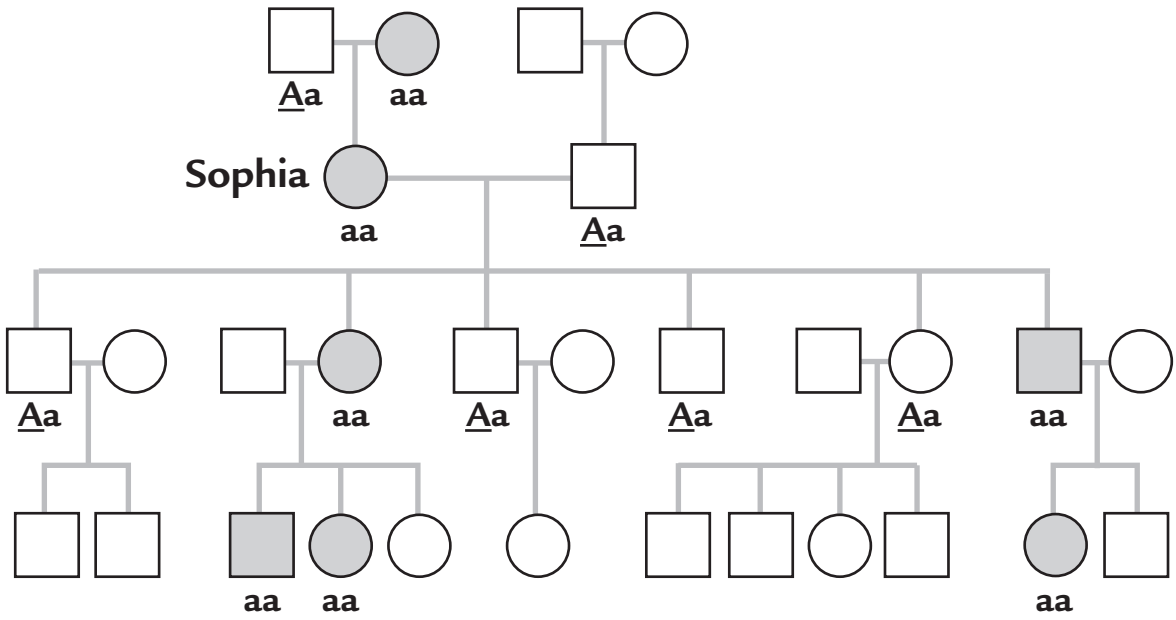


Question 3: A recessive trait

Three Kinds of Human Pedigrees (cont.)



Likely to be a dominant trait



Possibly a recessive trait

Name _____ **Date** _____

Pedigree Puzzles

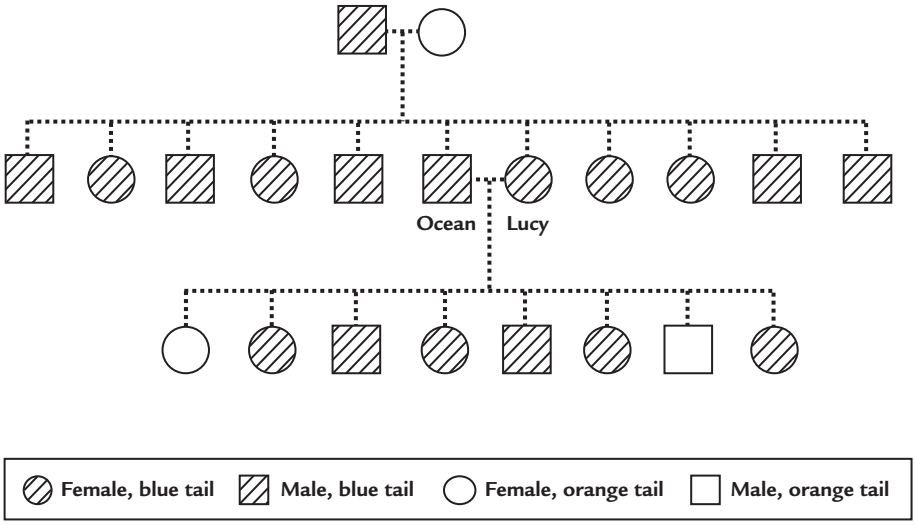


Figure 1: Critter Tail-Color Pedigree

This pedigree examines the tail-color trait in the family of critters bred in the zoo.

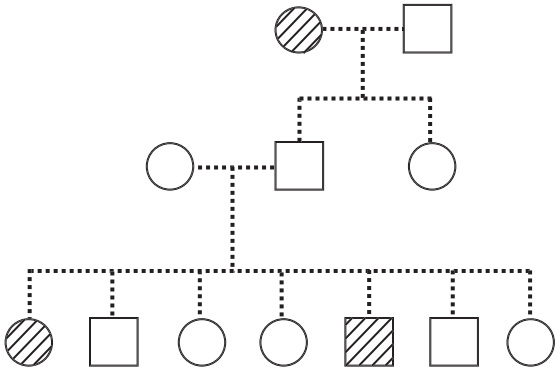


Figure 2: Family with PKU

Affected individuals are shaded.

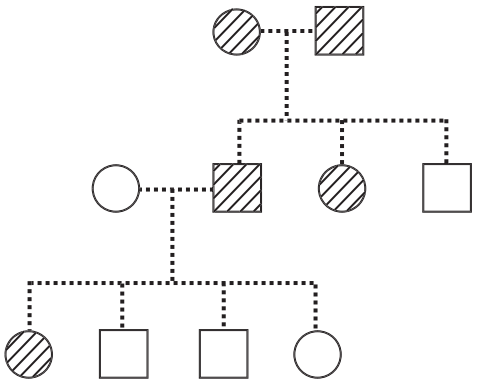


Figure 3: Family with Polydactyly

Affected individuals are shaded.

Name _____ **Date** _____

Pedigree Puzzles (cont.)

The pedigrees from many families suggest the results below.

Table 1: ABO Blood Types

Parents' Blood Types		Children's Possible Blood Types
O	O	O
A	O	A or O
B	O	B or O
A	A	A or O
B	B	B or O
A	B	AB, A, B, or O

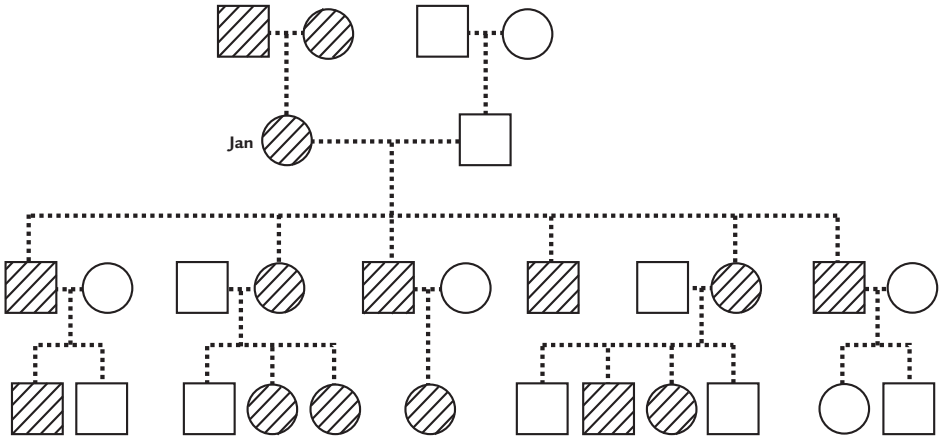
Workspace

Based on these results, figure out the possible allele pairs for each of the four blood types. It may help to make up one or two small pedigrees based upon specific rows of Table 1, using the workspace above.

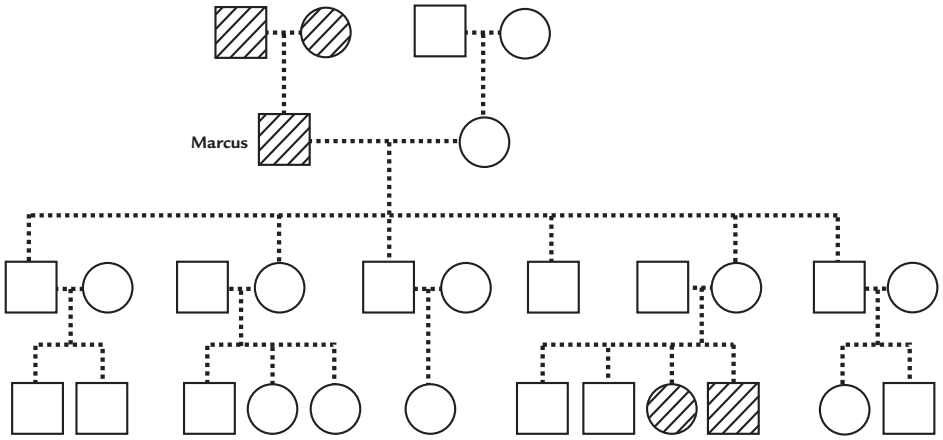
Blood Type	Possible Allele Pairs
O	_____
A	_____ or _____
B	_____ or _____
AB	_____

Name _____ Date _____

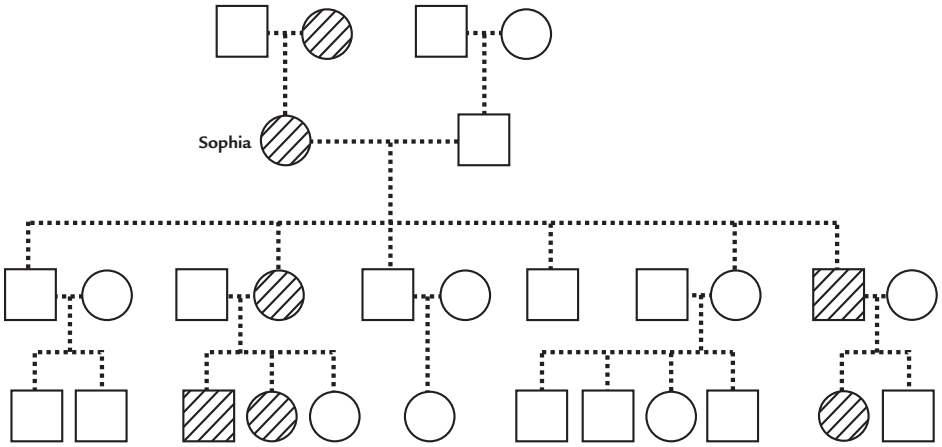
Pedigree Puzzles (cont.)



Analysis Question 2



Analysis Question 3



Analysis Question 4