

## Chapter 2: Genetics

### Practice, page 80

1.
  - a. Chromosomes and cookbooks both hold and pass on instructions for making products. Even though both have many instructions, only the needed instructions are used for any particular purpose.
  - b. There are many possible answers to this question. One difference is that genetic information is not organized by topic in chromosomes as the data is in a cookbook. For example, all the gene instructions for making a hand are not located on one specific chromosome but are spread out over several chromosomes.
2. In an individual hand cell there are 23 pairs of chromosomes for a total of 46.
3. The X-shape is due to the fact that chromosomes replicate before the process of mitosis begins and then coil during mitosis, which makes them thicker and more visible. The replicated chromosomes are attached at the centromere to give them an X-shape.
4. A *double helix* refers to the distinctive twisted ladder shape of the DNA molecule.

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5. Genes are designed to produce large, complex molecules called proteins. These molecules are a broad category of substances that include enzymes, hormones, transport proteins in cell membranes, and contractile proteins that allow muscles to contract.
6. Proteins in cell membranes serve a key role to form channels and pumps that allow needed materials to flow into the cell and keep unwanted materials out.

### Practice, page 86

7.
  - a. The answer key for the missing labels can be found on the graphic labelled “Mitosis” in the textbook.
  - b. The original cell at the top should be labelled “2n” and the two daughter cells at the bottom should also be labelled “2n,” since all of these cells have two copies of each chromosome.
8.
  - a. The answer key for the missing labels can be found on the graphic labelled “Meiosis” in the textbook.
  - b. The original cell at the top should be labelled “2n” since this cell has two copies of each chromosome. The four gametes at the bottom should each be labelled “1n” because these cells each have only one copy of each chromosome.

### Practice, page 90

9.
  - a. With selective breeding, people define which characteristics will be identified as most desirable. Humans then influence the outcome by selecting which individual organisms will be permitted to breed and produce offspring with these desirable characteristics.

In the case of natural selection, the environment defines which traits are desirable by establishing survival conditions. In this way, the environment also selects which individuals will be able to survive, reproduce, and pass on their advantageous traits to their offspring.

- b. Both natural selection and selective breeding use sexual reproduction and genetics to pass on desirable traits from parents to offspring.
10. a. Selective breeding is a form of genetic engineering because by selecting which individual organisms can reproduce, the genes able to join in fertilization are being manipulated to achieve desirable offspring characteristics.
- b. Through their farming practices, the first people to practise genetic engineering in Canada were First Nations people. Some scientists have estimated that it may have taken them about 7000 years of careful selective breeding to produce corn from the wild teosinite grasses.

## 2.1 Questions, page 92

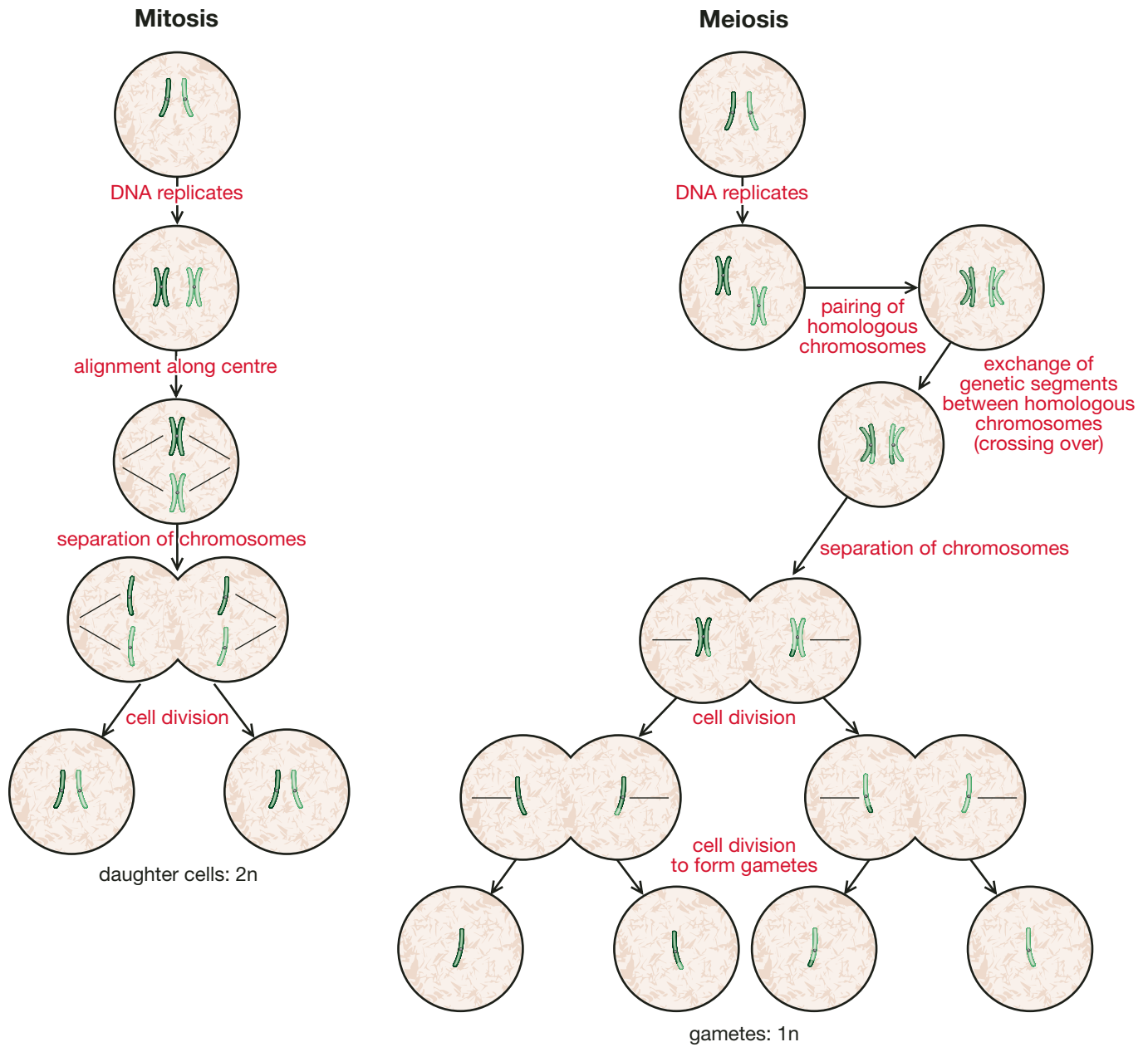
### Knowledge

1. a. chromosome      b. karyotype      c. protein      d. DNA      e. gene
2. There are 46 chromosomes or 23 pairs of chromosomes in a normal human autosomal cell. There are just 23 chromosomes in a normal human gamete.
3. The gender of an individual who has two *X* chromosomes in each autosomal cell is female.
4. There will always be an even number of chromosomes because both parents each donate the same number of chromosomes to their offspring.
5. Without meiosis, the child would have four sets of genetic information. This could make the reading of instructions for making proteins confusing or difficult. Also, space in the cell is limited. If meiosis did not occur, each new generation would obtain more and more genetic information, which would make the nucleus overly full and the information too difficult to manage.
6. Mendel used the term *factor* instead of *gene*.
7. Pea plants are well suited for genetic studies because they are easy to grow in large numbers, they self-pollinate, and they can be manipulated to cross with a desired individual. They have several distinctive traits that can be easily observed. In addition, they grow quickly when compared to other species.

**Applying Concepts**

8. a. and b.

**Comparing Mitosis and Meiosis—Labelled**



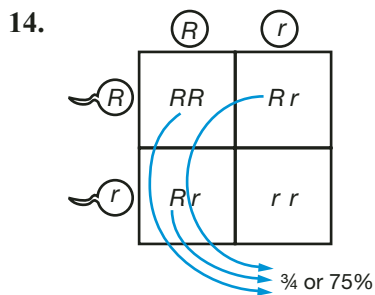
9. Some possible advantages of asexual reproduction include the following: there's no need to expend energy searching for a mate; asexual reproduction can be a very quick process; and a successful organism doesn't need to change its design.

10. The steps in the selective breeding process that would enable someone to produce a fast-running breed of dog might include the following:
- Begin with a breed of dog that is already known for its trait of fast running.
  - Take several members from a fast-running dog breed and mate them together.
  - Select the fastest offspring of the litters and mate those together.
  - Continue to cross only the fastest offspring until you have a very fast breed.
11. These scientists lacked powerful enough tools to see chromosomes or the mechanisms of the inheritance of genetic material. In the very male-dominated society of the time, it made sense to scientists that the male sperm would be the carrier of all offspring traits.

**Practice, page 94**

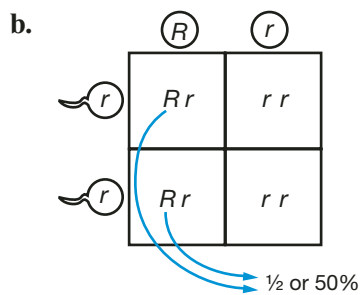
11. Answers will vary and may include a number of physical traits such as hair colour and eye colour. Responses may also include genetic diseases and conditions such as near-sightedness or colour blindness.
12. Answers will vary and may include any number of skills or interests developed through life experiences. Examples include languages spoken, sports skills, and injuries.
13. Based upon the information in the photograph, the little girls seem to have inherited the colour of their hair and skin from their mother. The shape of their eyes seems to be inherited from their father.

**Practice, page 96**



The percentage probability that their offspring will be able to roll their tongues is 75%.

15. a. No. The parent with the two copies of the recessive allele, *r*, is not a tongue roller.

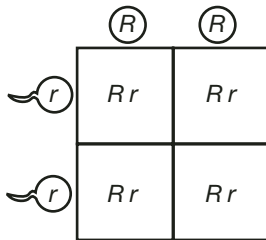


The percentage probability that their offspring will be able to roll their tongues is 50%.

### Practice, page 97

16. a. A homozygous tongue roller would have the alleles  $RR$ .  
 b. A heterozygous tongue roller would have the alleles  $Rr$ .  
 c. A homozygous non-tongue roller would have the alleles  $rr$ .

17. a.



- b. According to the Punnett square, 100% of the offspring will be able to roll their tongues.  
 c. According to the Punnett square, 0% of the offspring will not be able to roll their tongues.  
 d. According to the Punnett square, 100% of the offspring will be carriers of the recessive form of the non-tongue rolling gene.

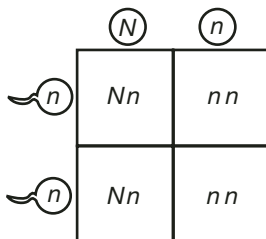
### Practice, page 98

18. a. The genotype  $NN$  results in a phenotype of fuzzy skin.  
 b. The genotype  $Nn$  results in a phenotype of fuzzy skin.  
 c. The genotype  $nn$  results in a phenotype of smooth skin—a nectarine.

19. a. A smooth-skinned nectarine has the genotype  $nn$ .

- b. If a fuzzy-skinned peach is bred from a cross between a peach-producing tree and a nectarine-producing tree, its genotype is  $Nn$ .  
 c. If a fuzzy-skinned peach is produced from a long line of peach-producing trees, its genotype is  $NN$ .

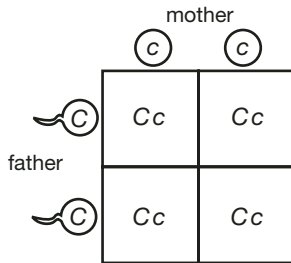
20. a.



- b. The percentage probability of each of the genotypes is as follows:  $NN = 0\%$ ;  $Nn = 50\%$ ; and  $nn = 50\%$ .  
 c. The percentage probability of offspring produced with the smooth-skinned nectarine phenotype is 50%, and the percentage probability of offspring produced with the fuzzy-skinned peach phenotype is also 50%.  
 d. According to the Punnett square, 100% of the offspring will carry the allele for smooth skin.  
 e. No, it is not possible for the nectarine to be heterozygous for the skin-type trait. If a nectarine had one dominant allele, this would make it possess the dominant fuzzy-skinned trait, which would make it a peach.

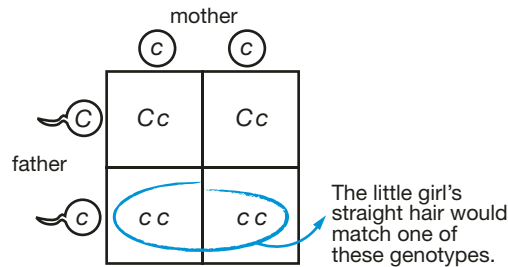
21. a. All of the offspring will have the heterozygous genotype of  $Tt$ .  
 b. All of the offspring will have the phenotype of being able to taste the PTC chemical.

22. a.



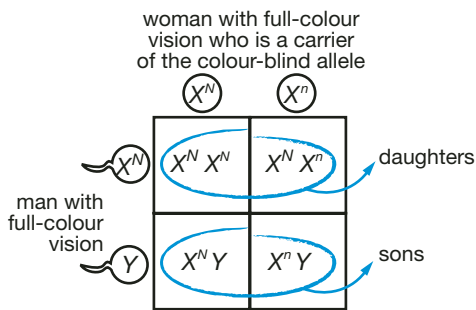
- b. The percentage probability that the couple's child will have curly hair is 100%.  
 c. The photo of the family on pages 76 and 77 of the textbook shows a mother with straight hair, a father with curly hair, and a little girl with straight hair. Assuming that the hair types shown are natural, and not due to work at a salon, the father must be heterozygous for curly hair, because if he were homozygous for curly hair, then his daughter would have to have curly hair, as shown in questions 22. a. and b.

Therefore, the following Punnett square would likely describe this situation:



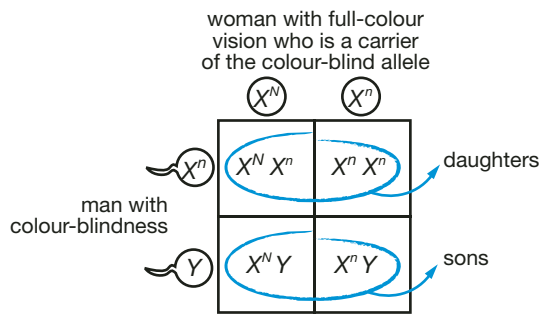
### Practice, page 101

23. a.



- b. There are two possible outcomes for the sons—one is colour-blind and one has full-colour vision. Therefore, the percentage probability that one of the sons will be colour-blind is 50%.  
 c. There are two possible outcomes for the daughters, and the recessive allele is present in just one of these. It follows that the percentage probability is 50% that one of the daughters has full-colour vision but is a carrier of the recessive allele for colour-blindness.

24. a.



- b. There are two possible outcomes for the sons—one is colour-blind and one has full-colour vision. Therefore, the percentage probability is 50% that one son will be colour-blind.
- c. There are two possible outcomes for the daughters—one is colour-blind and one has full-colour vision but is a carrier of the colour-blind allele. Therefore, the percentage probability is 50% that one daughter will be colour-blind.
- d. There are two possible outcomes for the daughters—one is colour-blind and one has full-colour vision but is a carrier of the colour-blind allele. Therefore, the percentage probability is 50% that a daughter has full-colour vision but is a carrier of the colour-blind allele.

25. The gene for colour-blindness is carried on the  $X$  chromosome, that males inherit only from their mothers. Fathers cannot pass on colour-blindness to their sons. Instead, the expectant father should look to his wife's father for more information. If her mother or father is colour-blind, the recessive allele was passed to her—this means that the percentage probability is 50% that the unborn son will inherit this recessive allele.

26. Males would be the only ones affected. Females do not possess a  $Y$  chromosome.

## 2.2 Questions, page 104

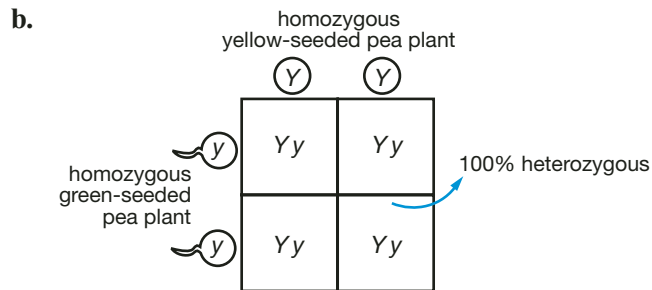
### Knowledge

1. Jim's genetically inherited traits include his hair colour, eye colour, and his curly hair. His acquired traits include his scar, his piano and skiing skills, and his love of winter sports.
2.
  - a. The dominant allele is represented by the uppercase letter  $M$ .
  - b. The recessive allele is represented by the lowercase letter  $m$ .
  - c. This is a heterozygous individual since the mouse has one copy of each different allele.
  - d. If black fur is dominant over white fur in mice, the mouse with the genotype  $Mm$  would be black rather than white since the mouse has one of the dominant black alleles for fur colour.
3.
  - a. The genotype for a ginger-coloured male cat is represented by  $X^G Y$ .
  - b. The phenotype of a cat with the genotype  $X^g Y$  is a black male cat.
  - c. The phenotype of a cat with the genotype  $X^G X^G$  is a ginger female cat.

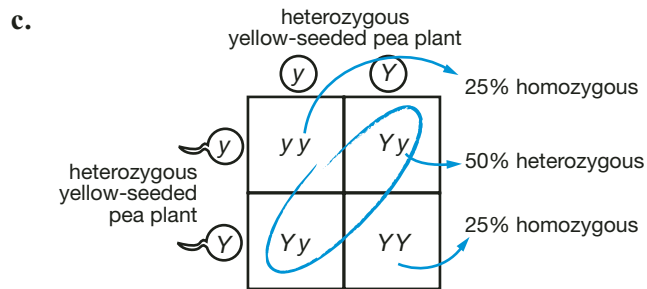
### Applying Concepts

4. The percentage probability of having a particular gender of baby is always 50% regardless of the gender of the previous children.

5. In autosomal inheritance, the genes are found on one of the 22 autosomal chromosomes. Gender does not influence how these genes are passed on. In sex-linked inheritance, the gene is found on at least one of the sex chromosomes and, therefore, the gender of the individual person influences his or her inheritance of the genes.
6. Letters used to represent alleles may vary, but the patterns should be similar to the following sample answers.
- a. If the yellow allele is  $Y$  and the green allele is  $y$ , a homozygous yellow-pea seed will have the genotype  $YY$ , a homozygous green-pea seed will have the genotype  $yy$ , and a heterozygous yellow-pea seed will have the genotype  $Yy$ .

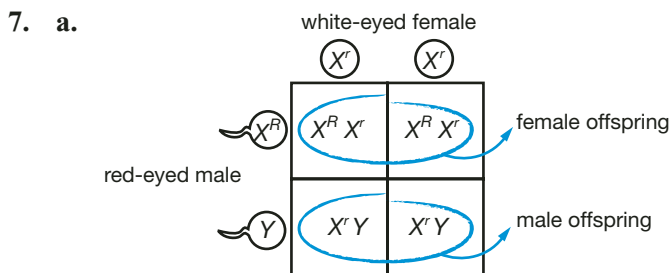


All the offspring will have the genotype of  $Yy$  and the yellow-seed phenotype.



Using the results from the Punnett square, the following frequencies are predicted. In terms of genotype, 25% will have the genotype  $yy$ , 50% will have the genotype  $Yy$ , and 25% will have the genotype  $YY$ .

In terms of phenotype, 75% will express the yellow-seed colour phenotype, and 25% will express the green-seed colour phenotype.



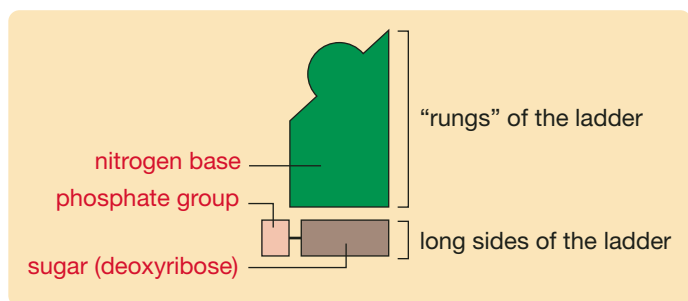
- b. There is only one possible outcome for the male offspring—they will have white eyes since they get their only  $X$  chromosome from their mother who carries two recessive alleles for white eyes on the  $X$  chromosome. Therefore, the percentage probability that males will have white eyes is 100%.



- c. The percentage probability of the female offspring having white eyes is 0%. This is because the females must inherit an *X* chromosome from the father, who carries the allele for red-eye vision on his *X* chromosome.
- d. There is only one possible outcome for the female offspring—they will have red eyes but they will be carriers for white eyes since they get their only *X* chromosome from their mother, who carries two recessive alleles for white eyes on the *X* chromosome. Therefore, the percentage probability that female offspring will be carriers of the recessive white-eyed allele is 100%.

### Practice, page 109

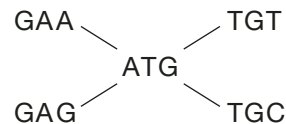
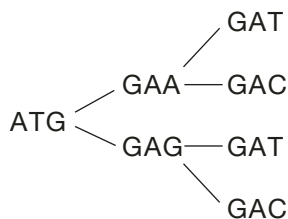
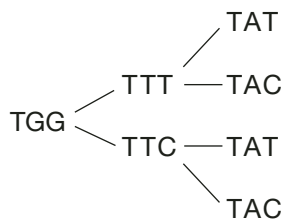
27. a. and b.



- 28. a. The complementary base pairs are adenine combined with thymine and cytosine combined with guanine.
- b. The nucleotides can pair up only in these combinations because the unique chemical structure of each nitrogen base ensures that associations (hydrogen bonds) can be formed only between adenine and thymine and between cytosine and guanine.
- 29. a. For the sequence AAATGTCGCCT, the complementary strand is TTTACAGCGGA.
- b. For the sequence TAGTCTA, the complementary strand is ATCAGAT.
- c. For the sequence GATTGATTCCGGGCTAA, the complementary strand is CTA ACTAAGGCCCGATT.
- 30. Counting from the left, the student has incorrectly matched up the third base pair. Adenine always bonds to thymine—not thymine to thymine.
- 31. Chargaff discovered that when DNA samples were tested, there was a one-to-one ratio between adenine and thymine. He found the same ratio between cytosine and guanine. Given our current understanding of the DNA molecule, this makes sense because adenine is always found bonded to thymine and cytosine is always found bonded to guanine. Since these compounds are always found in base pairs, there has to be equal proportions of the two nitrogen bases in a DNA molecule.
- 32. Franklin experimented with beams of X-rays passing through long strands of DNA. The re-emerging X-rays created X-shaped patterns on the other side of photographic film. Franklin interpreted these findings to mean that the X-rays had encountered a molecule shaped like a helix. This was early evidence of the helical structure of DNA.

## Practice, page 114

33. a. ATAAAGCGACTTCCC = Isoleucine-Lysine-Arginine-Leucine-Proline  
 b. AGAGGGGGTCTAGCC = Arginine-Glycine-Glycine-Leucine-Alanine  
 c. GTATTAGATTACGTTACA = Valine-Leucine-Aspartate-Tyrosine-Valine-Threonine
34. Since there is more than one way for DNA to code for some amino acids, there are several correct answers for this question. The following diagrams show how to generate all the possibilities.
- a. Tryptophan-Phenylalanine-Tyrosine    b. Methionine-Glutamine-Aspartate    c. Glutamine-Methionine-Cysteine



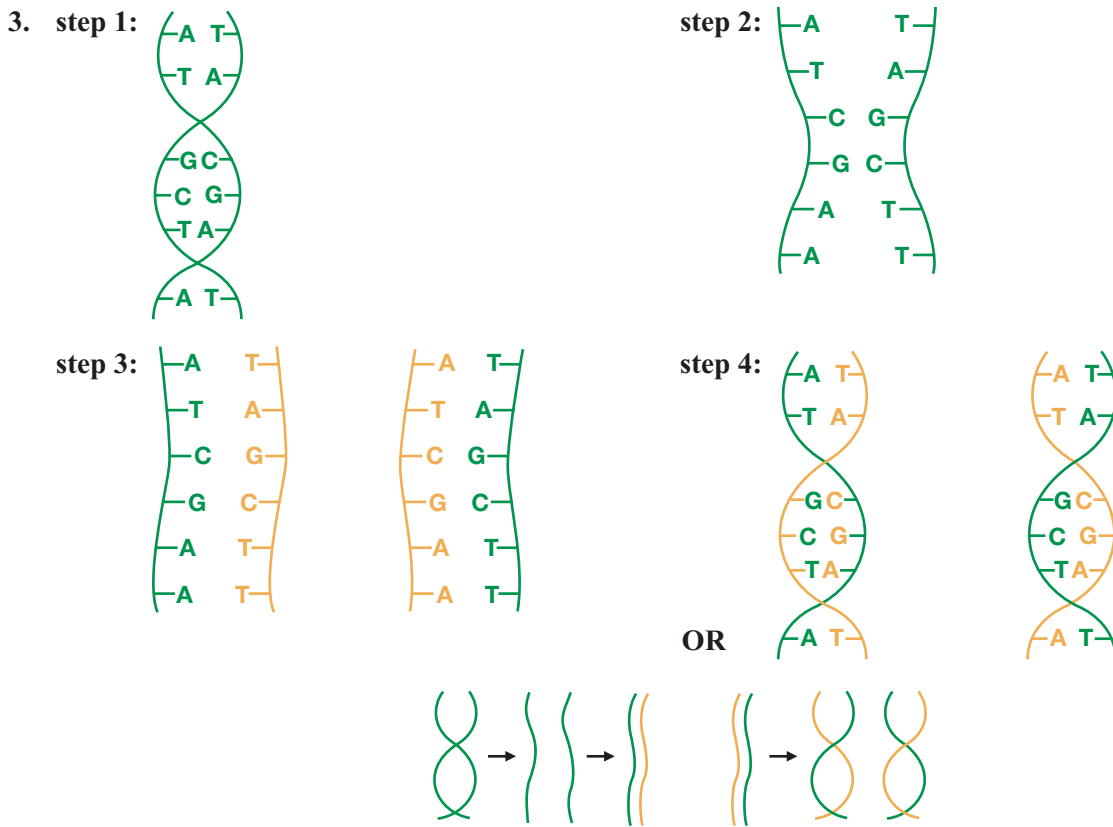
## 2.3 Questions, page 115

### Knowledge

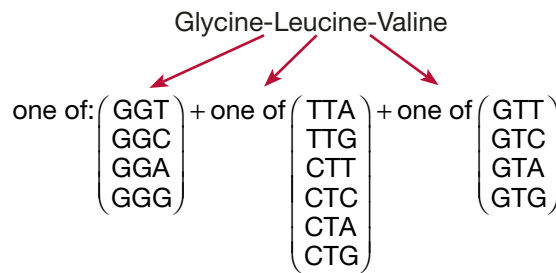
- False. A DNA triplet code is made up of three nitrogen base pairs and codes for one amino acid.
  - True. A DNA triplet code may code for the same amino acid as another DNA triplet code. For example, TTT and TTC both code for phenylalanine.
  - False. Adenine only bonds to thymine, and cytosine only bonds to guanine.
  - True.
  - True.
  - False. There are twenty different amino acids.
  - False. Histone is a type of protein that helps wind up and compact DNA.
  - True.
  - False. During replication, the two strands of DNA pull apart and free nucleotides attach to the exposed bases.
  - False. DNA is made up of two strands of nucleotides twisted together.

### Applying Concepts

- The sequence that would code for valine-alanine-asparagine is sequence III.



4. Since there is more than one way for DNA to code for some amino acids, there are several correct answers for this question. The following diagram shows how to generate all the possibilities.



5. This completed table compares protein synthesis to making a cake from a recipe.

Making a Cake	Protein Synthesis
• a library of cookbooks	• a karyotype of all the chromosomes for one individual
• a cookbook of recipes	• a chromosome
• a recipe for a particular cake	• a gene
• the words of the recipe	• DNA triplet code made up of nitrogen base letters
• ingredients that go into the cake	• amino acids
• the finished cake product	• protein

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35. a. It is a point mutation because a single nucleotide base was substituted.  
 b. The amino acid that corresponds to the triplet code TAT is tyrosine.  
 c. The triplet code TAA is a signal to stop adding to the amino acid chain.  
 d. Instead of producing the amino acid, tyrosine, the DNA instructions give the signal to stop making the amino acid chain. This means that if the amino acid chain does not get finished, the protein is incomplete.
36. a. This is a frameshift mutation because a nucleotide base was substituted.  
 b. The original DNA strand would have produced Glycine-Leucine-Glutamate.  
 c. The new, mutated DNA strand would have produced Glycine-Isoleucine-Argine.  
 d. With an addition of one nitrogen base at the beginning of this strand, the sequence codes for different amino acids for the rest of the chain. One unpaired base will be left at the end of the sequence.

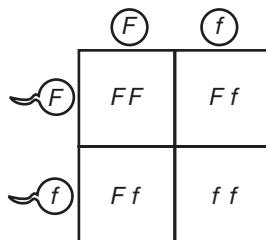
### Practice, page 120

37. Answers to this question will vary depending upon the genetic diseases known to exist in a particular family. Entering the phrase, "Is \_\_\_\_\_ a genetic disease?" in an Internet search engine may help separate genetic diseases from other conditions.

It is interesting to note that many diseases that are not solely genetic diseases may still have a genetic component. Strictly speaking, schizophrenia and breast cancer are not genetic diseases, but they seem to have genetic components. In these cases a faulty gene doesn't cause the disease, but there seems to be a genetic make-up that may make a person more susceptible to the disease.

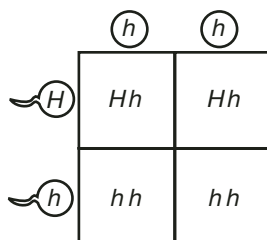
### Practice, page 121

38. a. Letters used to represent alleles will vary. In this sample answer, the letters  $Ff$  are used to represent a cross between two heterozygous individuals ( $Ff \times Ff$ ).

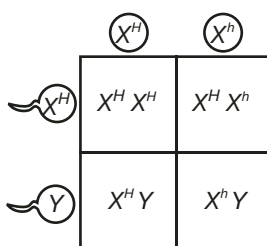


- b. The percentage probability that their child will develop cystic fibrosis is 25%. To develop cystic fibrosis, the child must be homozygous recessive ( $ff$ ) for the cystic fibrosis allele.
- c. The percentage probability that their child will be a carrier of the cystic fibrosis allele is 50%. To be a carrier of the cystic fibrosis allele, the child must have the genotype  $Ff$ .
- d. The percentage probability that their child will not inherit the cystic fibrosis allele is 25%. To not carry the cystic fibrosis allele, the child must be homozygous for the dominant allele of  $FF$ .

39. a. Letters used to represent alleles will vary. Huntington disease is caused by a dominant allele, so it should be an uppercase letter. In this sample answer, the letters  $Hh$  are used to represent a cross between two heterozygous individuals ( $Hh \times Hh$ ).



- b. The possible offspring genotypes from this cross are  $Hh$  and  $hh$ .
- c. The percentage probability that their child will not develop Huntington disease is 50%. Individuals with the genotypes  $hh$  will not express the trait or develop the disease.
- d. The percentage probability that their child will develop Huntington disease is 50%. Individuals with the genotype  $Hh$  will express the trait and will, therefore, develop the disease.
40. a. Letters used to represent alleles will vary. Since this is sex-linked, the letters  $X^H X^h$  represent the female who is not a carrier of hemophilia, and the letters  $X^H Y$  represent a man who is not a carrier.



- b. The percentage probability that she will have a child with hemophilia is 25%. Individuals with the genotype  $X^h Y$  will express the trait.
- c. Females can possess the genotypes  $X^H X^H$  or  $X^H X^h$  in this cross. Neither genotype will express the trait. Therefore, the percentage probability of a female developing hemophilia from this cross is 0%.
- d. Males can possess the genotypes  $X^H Y$  or  $X^h Y$  in this cross. The  $X^h Y$  genotype will express the trait; therefore the percentage probability of a male developing hemophilia from this cross is 50%.
41. Entering the name of the genetic disease and “Canada” in the search engine will provide you with the necessary websites to fully answer this question.

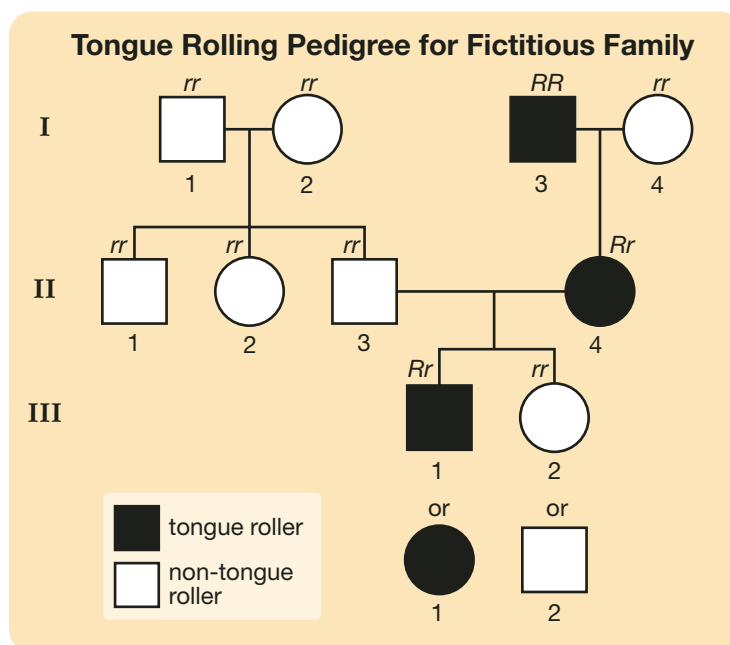
## Practice, page 124

42. a. The number of people with the albino condition includes two females and two males.
- b. Individual III-1 has albinism, but both her parents do not. This must mean that they are carriers for the genetic disease.

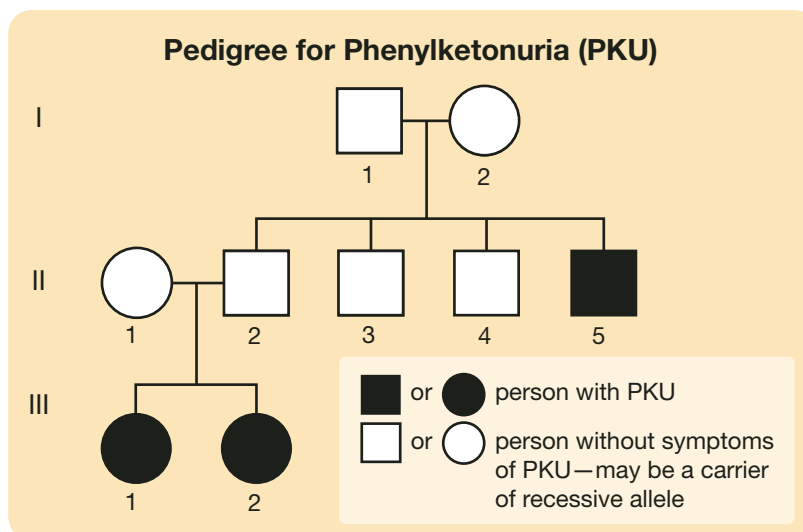
c. The non-albinism allele is  $A$ , and the albinism allele is  $a$ .

Individual	Likely Genotype	Individual	Likely Genotype
I – 1	$aa$	II – 4	$Aa$
I – 2	$Aa$	II – 5	$Aa$
II – 1	$Aa$	III – 1	$aa$
II – 2	$aa$		
II – 3	$aa$		

43. The following is a pedigree of the described family.



44. The following pedigree illustrates a family's genetic history for phenylketonuria.



## 2.4 Questions, page 128

### Knowledge

1. A *mutation* is a heritable change in the sequence of nitrogen bases along a DNA molecule.
2. A doctor may ask questions about your family’s medical history because some diseases or conditions have a complete or partial genetic component. When the doctor asks questions about your family medical history, the purpose is to assess your risk of developing certain heritable diseases.
3. Cystic fibrosis is a recessive autosomal disease, so a carrier has one non-mutated functioning copy of the gene. The functioning copy allows for the normal production of the protein, so the carriers are not themselves affected by the gene.
4.
  - a. In the first generation, the father is colour-blind.
  - b. Three males and two females were produced by the first generation father and mother.
  - c. Seven females are carriers for colour-blindness in this pedigree.
  - d. Six males and one female have colour-blindness.
5. Mutagens that can increase the frequency of mutations include exposure to ionizing radiation—such as UV lights and X-rays—and an exposure to chemical agents found in cigarettes and pesticides.

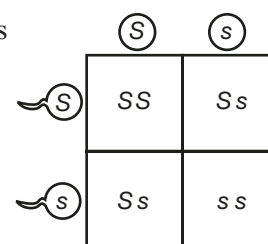
### Applying Concepts

6. The following table lists some of the similarities and differences between Punnett squares and pedigree charts.

Similarities	Differences
<ul style="list-style-type: none"> <li>• Both are visual and are designed to be created and interpreted quickly and easily.</li> <li>• Both are used for recording information about genetics.</li> <li>• Both can be used to examine the inheritance of genetic diseases or single traits.</li> </ul>	<ul style="list-style-type: none"> <li>• Punnett squares are used when genotypes are known and pedigrees are used to try to determine genotypes.</li> <li>• Pedigrees record information for several generations and crosses, while Punnett squares are used for a single cross.</li> <li>• Punnett squares are used to examine probabilities.</li> </ul>

7. People with Huntington disease often don’t develop symptoms until they are 30 or 40 years old. By this time, many of these people have already produced children, and may have unknowingly passed on Huntington disease to the next generation.
8. Your reproductive organs are usually shielded with lead sheets during an X-ray because X-rays are mutagens that can affect the DNA in cells. If a mutation occurs in the gametes (sex cells), it will appear in each cell of the developing offspring to result in an increased chance for genetic defects in the child. Higher doses of X-ray radiation can also cause sterility.

9. a. This Punnett square shows the probable results of the cross between two individuals who are both malaria resistant and heterozygous for the sickle cell trait.
- b. The possible genotypes from this cross are  $SS$ ,  $Ss$ , and  $ss$ .
- c. The offspring who are resistant to malaria are carriers with the genotype  $Ss$ . The percentage probability of a child of this cross being resistant to malaria is 50%.
- d. The offspring with sickle cell anemia have the genotype  $ss$ . Therefore, the percentage probability of a child of this cross developing sickle cell anemia is 25%.
- e. There is a benefit to having the sickle cell anemia allele in areas where there is a high incidence of malaria. People who have the allele are more likely to survive an outbreak of malaria and reproduce—they will then pass the allele on to their offspring. Since individuals with the allele have an advantage over those without the allele, over many generations the number of people with the allele will increase.
10. a. Since there is no history of hemophilia in any of Victoria's ancestors, the gene responsible for hemophilia must have occurred as a mutation.
- b. The individuals with hemophilia are only males in this pedigree because the gene defect that causes hemophilia is on the  $X$  chromosome. There is a greater chance that a male will have the disease since he only has one  $X$  chromosome. Females have two  $X$  chromosomes, so there is often a backup or unaffected copy of the gene.
- c. There are question marks written on some of Queen Victoria's female descendants because if they did not have hemophilia, it would be difficult to tell if they were carriers. You can only tell if these females were carriers if they had sons who developed hemophilia.



### Practice, page 132

45. Answers will vary for this question. The sample response that follows represents one possibility.

If an employer or insurance company looks for genetic diseases on a person's DNA or genes associated with developing genetic conditions, they can assess what risk there is of insuring the person on that genetic basis. This might mean that the applicant does not get coverage for health problems related to the genetic diseases found by the employer. Applicants may have to pay higher premiums for the insurance. If an employee is found to be a carrier for a genetic disease, his or her children may also be refused coverage.

46. Answers will vary for this question. The sample response that follows represents one possibility.

One benefit of performing a genetic test for diseases on an unborn baby is that for some parents, discovering a genetic disease early on allows them to prepare for the birth of a child with the genetic disease.

One risk of performing a genetic test for diseases on an unborn baby is that if the genetic test is done through amniocentesis, there is a chance of infection from the procedure, which may possibly result in a miscarriage.

Discovering that the mother is pregnant with a child possessing a genetic disease may provide some parents with the option of having an abortion. This could be viewed as a risk or a benefit depending upon your point of view. A risk that follows from this is that incorrect test results may cause parents to abort a baby without the genetic disease that they believed the child possessed, or they may treat a child differently.



47. Answers will vary for this question. The sample response that follows represents one possibility.

Refusing to provide a blood, breath (for a Breathalyser), or a DNA sample can be viewed as an admission of guilt by the police and courts. A judge can order a genetic sample to be collected where there are reasonable grounds for suspecting that the person committed the crime in question. The Office of the Privacy Commissioner of Canada has outlined the legal guidelines for collecting DNA evidence.

### Practice, page 134

48. Answers will vary for this question. This is one possibility.

Most European countries require that the use of genetically modified food be listed on products so that consumers can make the choice to purchase them or not. Other countries, such as Canada, have the position that genetically modified foods are tested for safety and that manufacturers should not be punished for using them by being required to add additional data to their labels. It is voluntary for manufacturers selling goods in Canada to label their products.

49. Answers will vary for this question. Here is one possibility.

There are risks and benefits of using transgenics to create animals with organs compatible for transplant into humans:

- People who are suffering would not have to wait so long for organs. (benefit)
- There is a chance that some diseases that affect only the organ-donating organism could be transmitted to humans. (risk)
- Some animals, such as pigs, are being killed for meat consumption anyway, so their organs are plentiful, of appropriate size, and easy to access for transplant. (benefit)
- Raising animals for the sole purpose of killing them for their organs may be seen as unethical by animal rights activists, particularly if the animals lead lives of suffering due to genetic alteration (e.g., suppressed immune systems would make the animals sick more often). (risk)
- Genetically engineering organisms can create opposition among religious groups because some feel that these technologies are contrary to the natural unfolding of life as defined by their beliefs. (risk)

### Practice, page 138

50. Answers will vary for this question. Here is one possibility.

Viruses used in gene therapy have been genetically altered so they don't cause disease. A major concern about using a virus to deliver a gene is the chance that the virus could again become pathogenic. Also, there are concerns that the virus could indiscriminately insert the gene into the DNA. This may disrupt the instructions for another gene to solve one problem, but potentially create another problem.

51. Answers will vary for this question. The sample response that follows represents one idea.

Using this technology to create individuals with more desirable traits could lead to the production of "designer babies." Trying to "improve" the genes of a population or group of humans is called eugenics, which is based on one person's ideas or a group of people's opinions on what is desirable in a human. The practice of eugenics purposely reduces the genetic variety of a group, and some individuals with qualities considered undesirable may be prevented from reproducing, living, or even being born. In an extreme scenario, those people with money could create a class of genetically "superior" individuals who have access to better jobs and opportunities. This could create discrimination based on genes.

52. Answers will vary for this question. One possibility follows.

Some benefits of using genetically engineered bacteria instead of animal glands include the following:

- Many people would find it preferable to be using bacteria instead of pigs and other livestock.
- Many animals would be needed to produce a small amount of product. Bacteria are more reliable in terms of quantity that they can produce, so there is no shortage of the needed product.
- Bacteria require very little space/area to live and produce their product.
- Bacteria reproduce very quickly and can therefore produce large quantities of the needed product to meet an increased demand.
- The bacterial product is more pure with less chance of contaminants or of patients having adverse reactions to animal allergens.

53. Sample responses that follow represent some possible answers.

**a. Genetically Modified Onions**

**Manipulated Variable:** presence of eye-watering gene or a protein that causes eye-watering

**Responding Variable:** taste of onion

**Controlled Variables:** both types of onion tasted for comparison, the state of the onion (cooked or raw), the size of onions used, the age of onions used

**Experimental Design:**

- Find a large number of subjects of various ages who are willing to participate in the taste test. Inform them that they will be tasting genetically modified onions and unmodified onions.
- Have each subject taste an equal-sized piece of each onion (modified and unmodified). This should be done as a double-blind study where neither the people carrying out the test nor the participants know which onion is which until after the experiment is over.
- Have each subject report any taste difference between the two samples. Record this data.
- Analyze the data to see if a significant number of participants identify the genetically modified onion as tasting different than the unmodified onion.

**b. Genetically Modified Tomatoes**

**Manipulated Variable:** presence of antifreeze gene

**Responding Variable:** frost resistance

**Controlled Variables:** age of tomato, number of each variety tested, temperature of testing, length of exposure to cold temperature, similar size of tomatoes tested

### **Experimental Design:**

- Make two large groups of similar sized and aged tomatoes (one group for genetically modified and one group for unmodified).
- Before starting, determine criteria for a spoiled tomato, such as a percentage of fruit that has become soft or discoloured.
- Place both groups of tomatoes in a similar location at a low temperature ( $-2^{\circ}\text{C}$ ) for six hours.
- Observe the effect of the exposure on the tomatoes several hours after the exposure. Look for signs of freezing such as soft or discoloured spots.
- Compare the number of tomatoes considered spoiled in each group.
- Repeat the experiment with several lower temperatures.
- Determine if there is a difference between the two groups in terms of frost resistance.

### **c. Genetically Modified Canola**

**Manipulated Variable:** presence of herbicide-resistant gene

**Responding Variable:** crop yield

**Controlled Variables:** volume of water, type of soil crop is grown in, mass of fertilizer used, number of sunlight hours per crop

### **Experimental Design:**

- Plant one field with the genetically herbicide-resistant crop and two fields nearby with the non-genetically herbicide-resistant crop.
- Create a barrier between the three crops to prevent cross-pollination and the blowing of herbicide between crops.
- Spray the genetically modified crop and one of the unmodified crops with the strong herbicide. Leave one of the unmodified crops unsprayed to serve as a control.
- Observe the amount of weeds or pest plants that grow in the three crops.
- Harvest the crops and compare the amount of canola oil produced in each of the three crops.
- Determine if the genetically modified crop produces a significantly greater amount of canola oil than the other crops.

## 2.5 Questions, pages 140 and 141

### Knowledge

1. 

<ol style="list-style-type: none"> <li>a. genetic modification</li> <li>c. gene therapy</li> <li>e. transgenics</li> </ol>	<ol style="list-style-type: none"> <li>b. DNA fingerprinting</li> <li>d. recombinant DNA</li> </ol>
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2. Answers will vary for this question. The sample response that follows represents one of the possibilities.

Possible advantages include the following:

- Crops can be made to be more resistant to disease or pests so there is less dependency on sprayed insecticides.
- Crops can be made to grow in poor soil or in drought conditions to alleviate famine in poor agricultural regions.
- Crops can be made more nutritious to alleviate famine in poor agricultural regions.
- Crops can be made less likely to spoil so the transportation/shipping costs for consumers are lower.
- Crops can be made to produce more food to alleviate famine in poor agricultural regions.

3. Answers will vary for this question.

Possible risks of applying transgenics to produce a new type of organism include the following:

- The organism may negatively affect the environment in which it is grown (e.g., unintentionally killing monarch butterflies).
- The organism may cross-pollinate or interbreed with related species.
- Allergens may be present in genetically modified foods assumed to be allergen-free.
- Monstrous organisms may be created that lead difficult lives because of their genetic modification.
- Genetic engineering could be used to create dangerous organisms and bioweapons.

4. Genes cannot be inserted into each human cell for the organ that needs to be targeted. A virus works by inserting its genes into the DNA of cells. These tiny vectors can be used to place DNA into cells where needed.

### Applying Concepts

5. The banding pattern produced by the DNA fingerprint looks most similar to suspect 2.
6. A person who receives gene therapy will not pass on the repaired gene because the virus would not be inserted into the gametes that pass on the genetic information to the offspring. Gene therapy targets body cells.

7. The steps used to develop a strain of genetically engineered bacteria that produce large amounts of this factor to treat people who have hemophilia are as follows:
- (a) The isolated gene would be inserted into a plasmid.
  - (b) The plasmid would then be inserted into a bacterium.
  - (c) The bacterium would begin to produce the blood-clotting factor.
  - (d) As the bacterium divides into more bacteria, each would have a copy of the plasmid with the needed gene.
  - (e) The blood-clotting factor would be collected and distributed to people with hemophilia.
8. Answers will vary for this question.

The risks and benefits of a nation possessing a gene bank for its citizens could be as follows:

- Crimes could be more easily solved. (benefit)
- Based on their genetics, some people may be discriminated against. (risk)
- Statistics on the population's genetically predisposed diseases could be generated to allow a nation to identify health-care funding priorities. (benefit)
- Privacy may be compromised if employers, insurance companies, or unauthorized individuals gain access to the data bank. (risk)
- Researchers can identify genes that cause diseases, and that research may possibly lead to new cures and treatments to benefit all nations. (benefit)