5. Barr bodies are small dark spots of chromatin in the nucleus of some of the somatic cells of female mammals during the interphase of meiosis. Barr bodies result when one of the X chromosomes in females randomly becomes inactive in each cell.
6. (a) If the mother is heterozygous for the trait, then hemophilic male offspring are possible.
   (b) Only if the father is hemophilic and the mother is a carrier. This is highly unlikely.
7. (a) parents: $X^cY \times X^CX^C$
   F_1 generation

	X^c	Y
X^C	X^CX^c	X^CY
X^C	X^CX^c	X^CY

All have colour vision.

   (b) parents: $X^CY \times X^CX^c$
   F_1 generation

	X^C	Y
X^C	X^CX^C	X^CY
X^c	X^CX^c	X^cY

3/4 have normal colour vision
1/4 colourblind
1/2 of males are colourblind
all females have normal colour vision

   (c) father: X^cY, mother: X^CX^c or X^cX^c
   F_1 generation

	X^c	Y
X^C	X^CX^c	X^CY
X^c	X^CX^c	X^cY

	X^c	Y
X^c	X^cX^c	X^cY
X^c	X^cX^c	X^cY

Activity 5.3.1 (pages 168–169)

(a) Yes, white eye colour is sex linked in *Drosophila*, with the males showing the trait most often. This is because they need only one allele to express the phenotype. Students should compare their results to the results that would be expected if the traits are not sex-linked.

Case Study: Following the Haemophilia Gene (pages 169–170)

(a) Edward, Duke of Kent, was Queen Victoria's father.
(b) Queen Victoria and prince Albert had 9 children.
(c) Alice has genotype X^HX^h; Leopold has genotype X^hY.

(d) All of the daughters would have received an X^H chromosome from their father. The sons had a 50% chance of receiving an X^h from their mother.
(e) Yes, it is possible for a female to be haemophilic. Alexis and Alice of Athlone would be able to produce a haemophilic female offspring.
(f) Using a Punnett square shows that 25% of Albert and Victoria's children can be expected to be haemophilic. Albert and Victoria had 9 children, thus 2 (male) children would be expected to suffer from haemophilia.

Sections 5.1–5.3 Questions (page 171)

1. Genes, the units of heredity, are located on chromosomes. Homologous chromosomes separate during meiosis, and character traits of offspring are influenced by the genes inherited from the offspring's parents.
2. Mendel did not work with a microscope and didn't know where the genetic material was located. Later work showed that cell division in sex cells was different than in somatic cells. Mendel didn't have any evidence to show how genes were recombined from one generation to the next. Alleles from haploid cells recombine to form diploid cells. If Mendel had been aware of the process of meiosis he may have realized that the inherited factors that affect character traits are located on genes.
3. (a) (i) X^MX^m
   (ii) Ww
   (b) (i) Normal male has genotype X^MY.
   parents: $X^MX^m \times X^MY$
   F_1 generation

	X^M	X^m
X^M	X^MX^M	X^MX^m
Y	X^MY	X^mY

all females normal
1/2 of males have miniature wings

(ii) The normal male could have genotype WW or Ww.
F_1 generation

	W	w
W	WW	Ww
W	WW	Ww

all normal

	W	w
W	WW	Ww
w	Ww	ww

3/4 normal
1/4 wingless

(c) (i) All females are normal; the males are 50% normal, 50% miniature wings.
(ii) 75% of the offspring normal, 25% wingless are wingless.
(d) Any of the pairings $Ww \times Ww$, $ww \times Ww$, or $ww \times ww$ could produce offspring that are wingless. However, since the wingless condition is recessive lethal, only the first pairing is an actual possibility.

4. (a) parents: $X^nX^N \times X^nY$

F_1 generation

	X^n	X^N
X^n	X^nX^n	X^nX^N
Y	X^nY	X^NY

females: 1/2 normal, 1/2 notched
males: 1/2 normal, 1/2 dead

(b) This would require a male with X^NY, but this male would be dead.
(c) The male would be dead.

5. Since this form of diabetes is a recessive trait located on an autosomal chromosome, an individual must receive two *dd* alleles in order to develop the condition, regardless of gender. Consequently, the ratio of men to women with the condition is relatively close. Colourblindness, though, is a sex-linked trait. A female would need to inherit two recessive alleles in order to develop the condition, while a male would need to inherit only one recessive allele to develop the condition. Consequently, the ratio of men to women who are colourblind is much higher than the ratio of men to women with diabetes.
6. The son inherits the colourblind gene from the mother. The mother is X^CX^c. The father contributes the Y chromosome, which determines gender.
7. Haemophilia would present some dangers for females with the onset of menstruation and puberty. These problems could ultimately could result in death for a haemophilic, which means that the homozygous recessive condition is less likely to be passed on to offspring and becomes rare. However, colourblindness presents no such detrimental condition.

5.6 Practice (page 177)

1. DNA provides the directions that guide the repair of worn or damaged cell parts, and contains the information that allows the cell to be duplicated, allowing the continuity of life.
2. Chromosomes are made of roughly equal proportions of proteins and nucleic acids. The nucleic acids are composed of a ribose sugar, a phosphate group and one of four nitrogenous bases.
3. Nucleotides are the basic components of nucleic acids.
4. Because proteins and nucleic acids were found in roughly equal proportions in the chromosomes, it was reasoned that the complicated proteins were logical master molecules. Nucleic acids were thought to be too simple to contain the vast amount of information required to produce a cell.
5. James Watson and Francis Crick discovered the double-helix model of DNA in 1953.
6. X-ray diffraction images provided an outline of the DNA molecule.
7. Cytosine pairs with guanine and thymine pairs with adenine.

Try This Activity (page 183)

(a) suspect #3

(b) Student answers will vary.
The DNA evidence only proves that it is the suspect's blood on the window. It does not indicate when or how the blood came to be there. There might be other explanations for the appearance of the blood at the crime scene.

5.9 Practice (pages 183–184)

1. The fish DNA is broken down into its component nucleotides by enzymes in the digestive tract. These nucleotides are then used by your cells to make human DNA.
2. DNA fingerprinting is a method of identifying whether or not a sample of DNA came from a specific person. Everyone (except identical twins, triplets, etc.) has segments of DNA which are unique to them. DNA fingerprinting involves comparing the target DNA with a sample from the suspected owner. The samples are radioactively labelled, placed against X-ray film, and compared to see if they match.

Chapter 5 Review (pages 188–189)

1. The development of the light microscope allowed scientists to observe that chromosomes occurred in pairs that separated during meiosis. These chromosomes formed new pairs when the gametes united, and this suggested to scientists that hereditary information might be located on the chromosomes.
2. Sutton and Boveri observed that chromosomes come in pairs which segregate during meiosis. The chromosomes form new pairs when the egg and sperm unite. The paired chromosomes, or homologous chromosomes, supported Mendel's two factor explanation of inheritance. Sutton and Boveri knew that the expression of a trait was not tied to whether it was located in a male or female sex cell. Therefore, some structure in both sperm and egg cells must determine heredity. They deduced that Mendel's factors (genes) must be located on the chromosomes. The fact that humans have 46 chromosomes, but thousands of different traits, led Sutton to hypothesize that each chromosome contains many different genes.
Thomas Hunt Morgan discovered that some genes are located on sex chromosomes. From experiments on *Drosophila*, he discovered that females have an XX chromosome pair and males have an XY chromosome pair. Morgan also discovered various mutations in *Drosophila*. He noted that some of the mutations seemed to be linked to other traits. Morgan concluded that the two genes responsible for the traits must be located on the same chromosome. This added support to the theory that the genes were located on chromosomes.
Barbara McClintock believed that genes could exchange position on chromosomes. Previously, it was thought that chromosome structure was fixed, with the exception of a few new combinations that might occur because of crossing over. McClintock came to this conclusion by interpreting her results of experiments with Indian corn.
3 Proteins exhibit much greater diversity than do nucleic acids. Protein is a major component of the chromosomes and the chromosomes were believed to play an important role in heredity.
4. X-ray diffraction is a technique used to determine the shape of a molecule. An X ray is directed at the crystallized form of the molecule. The diffracted rays are then trapped by film. The pattern produced reveals the 3-D shape of the molecule. This technique allowed Watson and Crick to determine that DNA was a double-helix.

5. Scientists use models as visual devices that help them understand how things look, and to see the relationships between different parts. For example, molecule models (like the DNA model) are made much larger than the real thing, to help scientists learn how the different atoms interact. X ray diffraction provides a picture that indicates how different chemical bonds interact with one another.
6. Muscle cells and brain cells all contain the same DNA since they all came from the same initial cell.
7. Identical twins have identical or nearly identical DNA. (Some changes caused by environmental mutagens and crossing over may have occurred). This means that most of their proteins are identical, which makes their organs virtually identical and therefore easier to transplant.
8. Aristotle believed that hereditary factors from the male outweighed those from the female. Today, we know that the dominance of an allele is not determined by gender. By 1865, the year in which Mendel published his papers, many of these misconceptions had been cleared up. Nineteenth-century biologists knew that the egg and sperm unite to form a new individual, and it was generally accepted that factors from the egg and sperm were blended in developing the characteristics of the offspring. For example, it is known that the male's sperm cells determine the sex of the offspring, and that a male offspring's haemophilia is a sex-linked trait inherited from the female parent on the X-chromosome.
9. Let R represent the wild-type, or red, allele, and r represent the white allele.
parents: $X^RX^r \times X^RY$.
F_1 generation

	X^R	X^r
X^R	X^RX^R	X^RX^r
Y	X^RY	X^rY

3/4 wild-type
1/4 white

all females have wild-type eyes
half of the males have white eyes

10. parents: *XX, +/tra* × *XY, tra/tra*
F_1 generation

	X, +	*X, tra*
X, tra	*XX, +/tra*	*XX, tra/tra*
Y, tra	*XY, +/tra*	*XY, tra/tra*

all males are normal
1/2 of the females transform