parents: *XX, +/tra* × *XY, tra/tra* OR *XX, +/tra* × *XY, +/tra*

F_2 generation

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

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

all males normal

1/2 of the females transform

11. (a) Both parents are normal.
    (b) There is a 25% chance that parents #1 and #2 would have a haemophilic (male) child (all of the daughters will be normal, half the sons are expected to be haemophilic).
    (c) If parents #1 and #2 were to have another male child, there is a 50% chance that child will be haemophilic.
    (d) Female #4 has genotype X^HX^h; male #5 has genotype X^HY. Note that female child #7 is haemophilic, meaning she carries two haemophilic genes, one from each parent. Thus, her mother, female #4, must carry a haemophilic gene.
12. The allele is most likely sex-linked. The male only needs one mutated gene to express the phenotype, but the female requires two recessive genes.
13. The animal would be able to make its own food.
14. The disorder does not affect people until after they have reached reproductive age. The genes have already been passed on.
15. Many potential responses. The location of the cystic fibrosis gene may lead to new treatments, the most dramatic of which is gene replacement, but others potential treatments, such as isolating enzymes to understand gene action, may also be mentioned.
16. Students should consider both benefits and risks. Expect different answers. Scientific thinking will not tell them whether or not the research should be conducted.
17. (a) DMD is recessive. Females that carry the gene do not express the trait.
    (b) Yes, because it occurs in males more often than in females. Males only need one allele to express the phenotype.
    (c) Parent #1 has genotype X^DX^d; parent #2 has genotype X^DY.
    (d) The theoretical probability of a male inheriting the disorder is 1/2; the actual ratio in this problem is 1/3. The theoretical probability of a female being a carrier is 1/2; the actual ratio is 1/2.
    (e) Student answers will vary.
    (f) The sex of the child is important because male children are the ones affected (assuming the father does not have the disorder). If conducted properly, early genetic screening techniques should not have led to the termination of a normal child. However, ultrasound alone shows only the sex of the child, not the presence of DMD, so it's possible that male children were terminated without certainty that they had DMD.

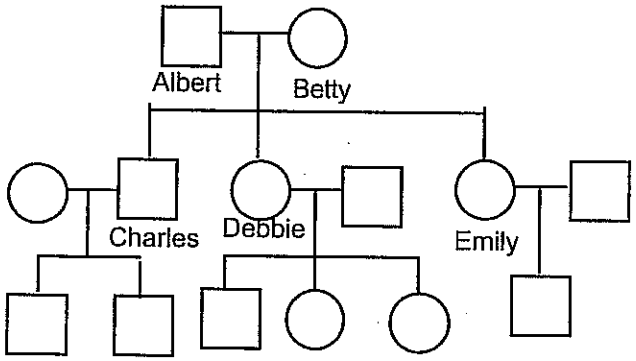
18. Many possible answers. McClintock herself felt that her ideas opposed the popular theories of the day. It should also be noted that new ideas are rarely accepted in science until they can be verified by other researchers.
19. DNA fingerprinting was first used in New Brunswick to convict a murderer. It has also been used to exonerate a number of high profile individuals such as Steven Truscott and Guy Moran, after they had been convicted. Many opinions can be explored. Students should be encouraged to listen to other viewpoints. Most importantly, students should recognize that the answer to the question is found not within the discipline of science but that of ethics. The question permits students to express their own opinions and justify their conclusions. This question also provides an example of the limits of the scientific paradigm for answering questions.

Unit 2 Performance Task (page 191)

(e) Myopia and colour vision are sex-linked.

(i) Answers will vary, but should include points such as using a questionnaire that was identical for all groups and a sample size as large as possible.

(j) (i) Affected individuals are indicated by shaded symbols.



(ii) The disorder only appears in men, and X-linked disorders occur more often in men. The disorder skipped the first generation, but then turned up Emily's son, suggesting that Emily was a carrier of the X-linked trait.

(ii) Emily has genotype *Xx*.

Unit 2 Review (pages 192–193)

1. Event (d) occurs before the end of the division phase of the cell cycle; event (c) occurs after.
2. (a) Stage 3 represents anaphase; stage 4 represents telophase.
   (b) During interphase all normal cell functions occur: cell growth, proteins building, duplication of cytoplasmic organelles, and the synthesis of new strands of DNA.
   (c) Cytokinesis is the stage at which division of the cytoplasm and the formation of separate daughter cells occurs.
3. (d)
4. (a)
5. (b)
6. (d) and (g) are correct.
7.

Organism	Diploid chromosome number (2n) before and after meiosis	Haploid chromosome number (n)
dog	78	39
human	46	23
fruit fly	8	4
cat	38	19
horse	66	33

8. (d)
9. (a) Process 3 represents mitosis.
   (b) Process 1 represents the division of diploid cells to produce haploid cells.
   (c) Process 3 represents the division of diploid cells to produce identical daughter cells.
   (d) Process 2 represents the union of haploid gametes to produce a diploid cell.
   (e) Process 1 represents meiosis.
10. (a) For animals, the gametes (egg and sperm) have a haploid chromosome number; For plants, the gametes and spores have a haploid chromosome number.
    (b) During fertilization the gametes come together and form a zygote.
11. Mendel's predecessors had hypothesized that the crossing of different traits would create a blend. Mendel proved that this was not the case. To test this idea, Mendel crossed the pollen from a wrinkled seed plant with the eggs from a round seed plant, and vice versa (pollen from a round seed plant with eegs from a wrinkled seed plant). In both cases, all the offspring were round. This showed that for some traits, some alleles are dominant over others.
12. (a)
13. (a)
14. Huntington's chorea is a neurological disorder caused by a dominant gene that only begins to express itself later in life. The disease is characterized by the rapid deterioration of nerve control, eventually leading to death. The disease can be detected by genetic screening, and gene therapy may be an option.
    Cystic fibrosis is an inherited disorder associated with a single gene, which produces a protein known as CFTR (cystic fibrosis transmembrane conductance regulator).

Cystic fibrosis results in abnormal fluid production in the lungs and pancreas. This fluid production causes difficulty in digestion and renders an individual highly susceptible to pneumonia. Those who suffer from cystic fibrosis must inherit two defective alleles, one from each parent. Cystic fibrosis is the most common recessive genetic disorder amongst people of European ancestry, affecting 1 in 25 people within this population. Dr. Lap-Chee Tsui led the team at the Hospital for Sick Children in Toronto that identified the gene in 1989. The group mapped two modifier genes in animals that alter the severity of cystic fibrosis, and they continue to investigate the impact that these modifier genes can have on the treatment of this disorder. It is hoped that defective genes may, one day, be replaced.

Muscular dystrophy is the name given to a group of genetic disorders that cause weakening and deterioration of muscles. Some forms of muscular dystrophy result from defects on autosomal chromosomes and may occur in both males and females. Other forms are sex-linked and affect mainly males. Some forms are due to recessive alleles and others are caused by dominant alleles. The rare form known as Emery-Dreifuss muscular dystrophy occurs in males as a result of a recessive X-linked gene. However, even female carriers can exhibit some mild symptoms. Dr. Ron Worton and his colleagues at the Hospital for Sick Children located the gene responsible for Duchenne muscular dystrophy in 1987. This is a sex-linked form that begins to affect boys between ages 2 and 6. They suffer progressive damage beginning in the muscles of the pelvis, upper arms, and legs. The calf muscles enlarge because the enzyme creatinine kinase leaks out from the muscles causing them to swell. Most boys with Duchenne are confined to a wheelchair by age 12.

15. (a)
16. (d)
17. Figure 8 is the strand of DNA complementary to the one in Figure 8.
18. (a) The mutant gene is dominant. More than 80% of individuals who have the mutant gene develop breast cancer.
    (b) The probability that one of the daughters will develop breast cancer is 1/2.
    (c) If the dominant gene was solely responsible for expression, then 100% of the women with the gene would develop breast cancer. Diet, exposure to harmful chemicals, or another gene may affect the expression of this gene.
    (d) If detection occurs before the cancer spreads (metastasis) it can be removed. Once the cancer spreads it becomes difficult to detect and remove.
    (e) It might prevent them from obtaining medical insurance or employment.
19. (a) parents: *YYRR* × *yyrr*

    F_1 generation

	YR	*YR*
yr	*YyRr*	*YyRr*
yr	*YyRr*	*YyRr*

all yellow and round

parents: *YyRr* × *YyRr*

F_2 generation

	YR	*Yr*	*yR*	*yr*
YR	*YYRR*	*YYRr*	*YyRR*	*YyRr*
Yr	*YYRr*	*YYrr*	*YyRr*	*Yyrr*
yR	*YyRR*	*YyRr*	*yyRR*	*yyRr*
yr	*YyRr*	*Yyrr*	*yyRr*	*yyrr*

9/16 round, yellow
3/16 round, green
3/16 wrinkled, yellow
1/16 wrinkled, green

(b)

Observed F_2 Phenotypes

Phenotype	**Theoretical**	**Actual**
round, yellow seeds	56.25%	56.65%
round, green seeds	18.75%	19.42%
wrinkled, yellow seeds	18.75%	18.16%
wrinkled, green seeds	6.25%	5.76%

Possible reasons for differences (which are small, and might not be considered significant) could be that: the results are random and cannot be completely predictable; the sample is not large enough.

20. (a) parents: $E^1E^4 \times E^2E^3$

F_1 generation

	E^1	E^4
E^2	E^1E^2	E^2E^4
E^3	E^1E^3	E^3E^4

1/2 wild-type
1/4 apricot
1/4 honey

(b) parents: $E^1E^4 \times E^3E^4$

F_1 generation

	E^1	E^4
E^3	E^1E^3	E^3E^4
E^4	E^1E^4	E^4E^4

1/2 wild-type
1/4 honey
1/4 white

21. (a) parents: $BbYY \times bbYy$

F_1 generation

	BY	*bY*
bY	*BbYY*	*bbYY*
by	*BbYy*	*bbYy*

1/2 green
1/2 yellow

(b) parents: $BbYy \times BbYy$

F_1 generation

	BY	*By*	*bY*	*by*
BY	*BBYY*	*BBYy*	*BbYY*	*BbYy*
By	*BBYy*	*BByy*	*BbYy*	*Bbyy*
bY	*BbYY*	*BbYy*	*bbYY*	*bbYy*
by	*BbYy*	*Bbyy*	*bbYy*	*bbyy*

9/16 green
3/16 blue
3/16 yellow
1/16 no colour

22. (a) The genotype of the female cat is *EeSspp*.

(b) The genotype of the male cat is *eeSspp*; the male cat has folded ears, smooth hair, and 5 digits.

(c) The probability of producing a cat with 6 or more digits is 1/2.

parents: $EeSspp \times EESsPp$

F_1 generation

	p	*p*
P	*Pp*	*Pp*
p	*pp*	*pp*

1/2 have 5 digits
1/2 are polydactyl

(d) The probability of producing a cat with pointed ears is 100%.

23.

Baby	**Baby's blood type**	**Couple**
baby A	O, Rh–	couple 4 (because type O, Rh– is the only type they could make)
baby B	AB, Rh–	couple 1 (because no other couple could make type AB)
baby C	O, Rh+	couple 2 (because couple 1 has already been eliminated and couple 4 could only make Rh–)
baby D	A, Rh–	couple 3 (because couple 1 has already been eliminated)

24. Many possible answers.

Benefit	Risk
offspring have identical phenotypes as the parents (e.g., plant breeding)	a lack of genetic diversity making extinction more likely
cloning for transplants	ethical considerations

25. (a) Fragmentation would affect cell division because fragments are not attached to spindle fibres.
    (b) Cellular examination could be used to detect these changes in chromosomes, e.g., amniocentesis.
26. Hugo DeVries studied evening primrose plants and determined that some alleles are codominant. The crossing of primrose plants with red and white coloured petals produced offspring with pink flowers. Herman Muller found that subjecting fruit flies to X-rays induced genetic mutations.
27. Many examples in the text.
28. Student answers will vary.