Chapter 2: Single gene inheritance

Problems 3, 40, 43, 46, 49, 18-19, 22, 27, 30, 13, 50, 53, 61

3. In Table 2-1, state the recessive phenotype in each of the seven cases.

TABLE 2-1 Results of All Mendel's Crosses in Which Parents Differed in One Character

Parental phenotypes	F_1	F_2	F_2 ratio
1. round × wrinkled seeds	All round	5474 round; 1850 wrinkled	2.96:1
2. yellow × green seeds	All yellow	6022 yellow; 2001 green	3.01:1
3. purple × white petals	All purple	705 purple; 224 white	3.15:1
4. inflated × pinched pods	All inflated	882 inflated; 299 pinched	2.95:1
5. green × yellow pods	All green	428 green; 152 yellow	2.82:1
6. axial × terminal flowers	All axial	651 axial; 207 terminal	3.14:1
7. long × short stems	All long	787 long; 277 short	2.84:1

Table 2-1
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Answer:
wrinkled seeds; green seeds; white petals; pinched pods; yellow pods; terminal flowers; short stems

40. In the plant *Arabidopsis thaliana*, a geneticist is interested in the development of trichomes (small projections). A large screen turns up two mutant plants (A and B) that have no trichomes, and these mutants seem to be potentially useful in studying trichome development. (If they were determined by single-gene mutations, then finding the normal and abnormal functions of these genes would be instructive.) Each plant is crossed with wild type; in both cases, the next generation (F1) had normal trichomes. When F1 plants were selfed, the resulting F2's were as follows:

- F2 from mutant A: 602 normal; 198 no trichomes
- F2 from mutant B: 267 normal; 93 no trichomes

a. What do these results show? Include proposed genotypes of all plants in your answer.
b. Under your explanation to part a, is it possible to confidently predict the F1 from crossing the original mutant A with the original mutant B?

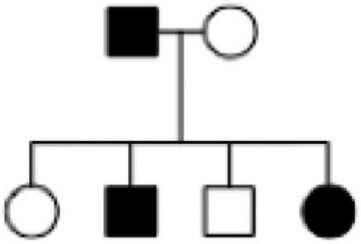
Answer:
The data indicates that each mutant is homozygous recessive for a mutation that inhibits trichome development (aa). When crossed with wild-type plants (AA), all F1 progeny were normal suggesting the following cross:

	a	a
A	Aa	Aa
A	Aa	Aa

Thus, the F1 progeny were all heterozygous and their offspring display the expected 3:1 ratio from the following cross:

	A	a
A	AA	Aa
a	Aa	aa

43. In the pedigree below, the black symbols represent individuals with a very rare blood disease. If you had no other information to go on, would you think it more likely that the disease was dominant or recessive? Give your reasons.



Answer:
If the disease were recessive, it would mean that the father has two copies of the allele, and the mother has one. Otherwise, the children could not be affected – for them to have a recessive phenotype, they must each inherit one allele from each parent! And yet, you are told this disease is very rare. If it is dominant, it simply means the father has one copy of the allele and he passed it to each of the parents. Thus, the disease is likely dominant.

46. Suppose that a husband and wife are both heterozygous for a recessive allele for albinism. If they have dizygotic (two-egg) twins, what is the probability that both the twins will have the same phenotype for pigmentation?

Answer:
Both parents are A/a. Both twins could be albino or both twins could be normal (for probability calculations: and = multiply, or = add). The probability of being normal is the probability of having one dominant allele (A/–) – $\frac{3}{4}$. The probability of being albino is the probability of having two recessive alleles (a/a) – $\frac{1}{4}$.
p(both normal) + p(both albino) =
p(first normal) × p(second normal) + p(first albino) × p(second albino) =
$\frac{3}{4} \times \frac{3}{4} + \frac{1}{4} \times \frac{1}{4} = \frac{9}{16} + \frac{1}{16} = \frac{5}{8}$

49. In nature, the plant *Plectritis congesta* is dimorphic for fruit shape; that is, individual plants bear either wingless or winged fruits. Plants were collected from nature before flowering and were crossed or selfed with the following results:

Pollination	Winged	Wingless
Winged (selfed)	91	1
Winged (selfed)	90	30
Wingless (selfed)	4	80
Winged x wingless	161	0
Winged x wingless	29	31
Winged x wingless	46	0
Winged x winged	44	0
Winged x winged	24	0

Answer:

Pollination	Genotypes	Winged	Wingless
Winged (selfed)	AA x A-	91	1
Winged (selfed)	Aa x Aa	90	30
Wingless (selfed)	aa x aa	4	80
Winged x wingless	AA x aa	161	0
Winged x wingless	Aa x aa	29	31
Winged x wingless	AA x aa	46	0
Winged x winged	AA x A-	44	0
Winged x winged	AA x A-	24	0

The five unusual plants are most likely due either to human error in classification or to contamination. Alternatively, they could result from environmental effects on development. For example, too little water may have prevented the seedpods from becoming winged, even though they are genetically winged.

18. Name the key function of mitosis.

Answer:

The key function of mitosis is to generate two daughter cells that are genetically identical to the original parent cell.

19. Name two key functions of meiosis.

Answer:

Two key functions of meiosis are to halve the DNA content and to reshuffle the genetic content of the organism to generate genetic diversity among the progeny.

22. In what ways does the second division of meiosis differ from mitosis?

Answer:

As cells divide mitotically, each chromosome consists of identical sister chromatids that are separated to form genetically identical daughter cells. Although the second division of meiosis appears to be a similar process, the "sister" chromatids are likely to be different. Recombination during earlier meiotic stages has swapped regions of DNA between sister and nonsister chromosomes such that the two daughter cells of this division typically are not genetically identical.

27. If children obtain half their genes from one parent and half from the other parent, why aren't siblings identical?

Answer:

Because the "half" inherited is very random, the chances of receiving exactly the same half is vanishingly small. Ignoring recombination and focusing just on which chromosomes are inherited from one parent, there are $22^3 = 8,388,608$ possible combinations!

30. Four of the following events are part of both meiosis and mitosis, but only one is meiotic. Which one? (1) chromatid formation, (2) spindle formation, (3) chromosome condensation, (4) chromo- some movement to poles, (5) synapsis

Answer:

(5) synapsis (chromosome pairing)

13. Could the pedigree in Figure 2-31 be explained as an autosomal dominant disorder? Explain.

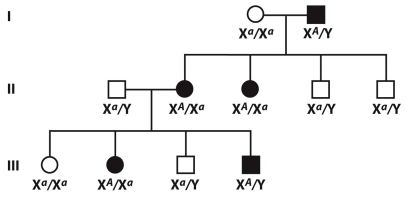


Figure 2-31
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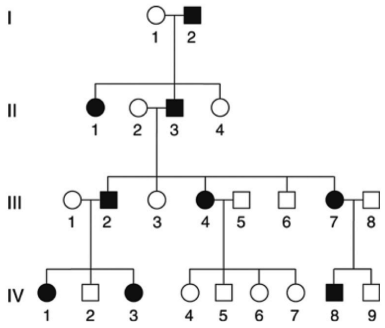
Answer:

50. The accompanying pedigree is for a rare but relatively mild hereditary disorder of the skin.
    a. How is the disorder inherited? State reasons for your answer.
    b. Give genotypes for as many individuals in the pedigree as possible. (Invent your own defined allele symbols.)
    c. Consider the four unaffected children of parents III-4 and III-5. In all four-child progenies from parents of these genotypes, what proportion is expected to contain all unaffected children?



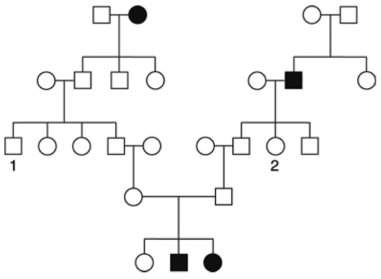
Answer:

a.

b.

c.

53. The following pedigree was obtained for a rare kidney disease.
    a. Deduce the inheritance of this condition, stating your reasons.
    b. If persons 1 and 2 marry, what is the probability that their first child will have the kidney disease?



Answer:

a.

b.

61. Duchenne muscular dystrophy is sex-linked and usually affects only males. Victims of the disease become progressively weaker, starting early in life.
    a. What is the probability that a woman whose brother has Duchenne's disease will have an affected child?
    b. If your mother's brother (your uncle) had Duchenne's disease, what is the probability that you have received the allele?
    c. If your father's brother had the disease, what is the probability that you have received the allele?

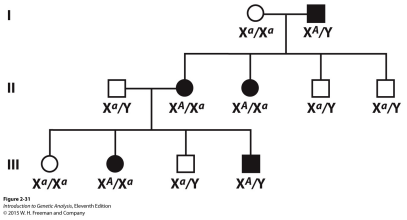


Figure 2-31
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Answer:

a.

b.

c.