

From: <http://www.nwmissouri.edu/~KHABER/102genetics.doc>

HINT - A general strategy in solving such problems is:

- Decide on symbols to represent the alleles, and which is dominant (if given).
- Write out the genotypes as completely as possible all individuals.
- See what's asked in the problem.
- Take steps to find the answer (maybe Punnett square or backtracking).
- Check to make sure the result is consistent with the conditions of the problem.

1. In the fruit fly, vestigial wings and hairy body are produced by recessive alleles on two different chromosomes. If a vestigial winged, hairy male is crossed with a homozygous normal female, what ratios of phenotype and genotype do you expect in the F1 and F2 generations?

2. When two short-tailed cats mate, about half of the kittens have short tails, a quarter have long tails, and a quarter have no tails. What is the simplest genetic explanation for the inheritance of this trait?

3. In peas, the allele for tall plants (T) is dominant over the allele for short plants (t). On a separate chromosome, the allele for smooth peas (S) is dominant over the allele for wrinkled peas (s). Calculate phenotypic ratios for the following crosses:

TtSs x TtSs TtSs x ttss ttSs x Ttss TTss x ttSS

4. In roses, flower color is determined by red and white alleles, which are codominant. If a breeder wants to produce offspring that are all pink, what types of plants should he cross? Why aren't these pink plants true breeding?

5. What is the probability of having four children of the same sex?

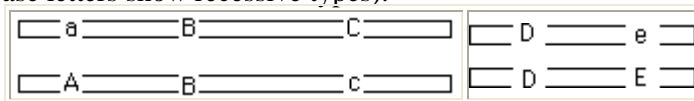
6. Allele "b" is sex-linked, recessive, and lethal. Suppose a man marries a woman who is heterozygous for this gene. What is the chance that the next son or the next daughter will carry the allele? What will be the ratio of surviving boys to surviving girls?

7. In the "ABO" blood system, alleles A and B are each dominant to O, but codominant with each other (remember that a single person has two alleles, so the possible phenotypes are A, B, AB, and O). In a paternity suit, a woman with the A blood type claims her son (type O blood) was fathered by a man with type AB blood. As a geneticist called to testify, what do you tell the judge? What are the possible genotypes of the mother?

8. A woman, whose maternal grandfather had hemophilia (X-linked recessive), has parents who seem to be normal. She, too, seems normal, as does her husband. What are the genotypes of the woman, her parents, her maternal grandparents, and her husband? What are the chances that her first son will be normal?

From: <http://members.aol.com/BearFlag45/Biology1A/Problems/genprob1.html>

9. The diagrams show 2 pairs of homologous chromosomes, with 5 genes marked out. (Capitals show dominant types and lower case letters show recessive types).



Which gene(s) are homozygous? _____.

Which are heterozygous? _____.

Which gene(s) are linked to gene A? _____.

Which gene is most likely to become unlinked from A by crossing over? _____.

10. If a female has the 2 chromosomes shown above what kind of egg cells can she make? Make a set of diagrams

showing the distribution of the A, B, C, D and E genes in the different types of eggs that she could produce.

11. You have some pea plants with yellow seeds, but don't know whether they are pure or hybrids. In peas yellow seeds are dominant over green seeds. Show on Punnett diagrams how you would do a testcross to determine whether plants with yellow seeds are pure or hybrid (use the symbol Y for yellow and the symbol y for green).

12. A man with type A blood and a woman with type B give birth to a child with type O blood. Both parents are upset because the child does not have blood matching either of their types. Is it possible that the man and woman are the parents of the child?

13. You are crossing pure wild type fruit flies with red eyes with a pure line that has a mutant gene for white eye color. You observe a strange result. The male always switches phenotype in the F1 generation. If you use a mutant male the F1 males have red eyes. If you use a normal male the F1 males have white eyes. Use Punnett diagrams to show how this can occur. What are the phenotypes of the females in these crosses?

14. Do a dihybrid cross, for the 2 genes, B & E controlling coat color in the Labrador retriever. Here are the rules for the 2 genes:

- Color involves 2 genes, B & E
- B produces color; E deposits color in coat
- BB or Bb -> black color; bb -> chocolate brown color
- EE or Ee -> color deposited in coat, dogs have color determined by B gene; ee -> color not deposited in coat, dogs are yellow
- cross F1 hybrids (BbEe X BbEe)

From: <http://www.biology.uc.edu/faculty/snider/GENPROB.HTM>

15. If the litter resulting from the mating of two short-tailed cats contains three kittens without tails, two with long tails, and six with short tails, what would be the simplest way of explaining the inheritance of tail length in these cats? Show genotypes.

16. In peas a gene for tall plants (T) is dominant over its allele for short plants (t). The gene for smooth peas (S) is dominant over its allele for wrinkled peas (s). Calculate both phenotypic ratios and genotypic ratios for the results of each of the following crosses:

T/t S/s x T/t S/s; T/t s/s x t/t s/s; t/t S/s x T/t s/s; T/T s/s x t/t S/S

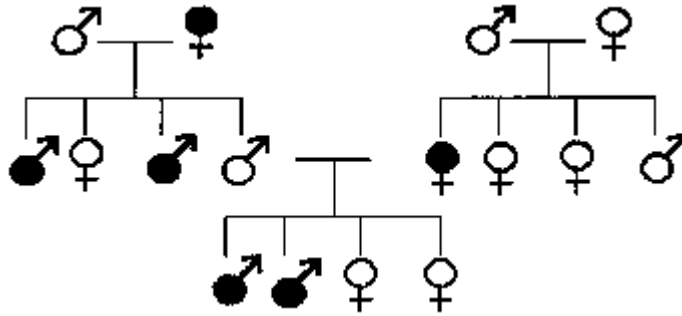
17. In hogs a gene that produces a white belt around the animal's body is dominant over its allele for a uniformly colored body. Another independent gene produces fusion of the two hoofs on each foot (an instance of syndactyly), it is dominant over its allele, which produces normal hoofs. Suppose a uniformly colored hog homozygous for syndactyly is mated with a normal-footed hog homozygous for the belted character. What would be the phenotype of the F1? If the F1 individuals are allowed to breed freely among themselves, what genotypic and phenotypic ratios would you predict for the F2?

18. In watermelons the genes for green color and for short shape are dominant over their alleles for striped color and for long shape. Suppose a plant with long, striped fruit is crossed with a plant heterozygous for both of these characters. What phenotypes would this cross produce and in what ratios?

19. In the fruit fly *Drosophila melanogaster*, vestigial wings and hairy body are produced by two recessive genes located on different chromosomes. The normal alleles, long wings and hairless body, are dominant. Suppose a vestigial-winged, hairy male is crossed with a homozygous normal female. What types of progeny would be expected? If the F1 from this cross are permitted to mate randomly among themselves, what progeny would be expected in the F2? Show complete genotypes, phenotypes, and ratios for each generation.

20. Suppose a hairy female heterozygous for vestigial wing is crossed with a vestigial-winged male heterozygous for the hairy character. What will be the characteristic of the F1?

21. In some breeds of dogs a dominant gene controls the characteristic of barking while trailing. In these dogs another independent gene produces erect ears, it is dominant over its allele for drooping ears. Suppose a dog breeder wants to produce a pure-breeding strain of droopy-eared barkers, but he knows the genes for silent trailing and erect ears are present in his kennels. How should he proceed?
22. A dominant gene, A, causes yellow color in rats. The dominant allele of another independent gene, R, produces black coat color. when the two dominants occur together (A/- R/-), they interact to produce gray. Rats of the genotype a/a/ r/r/ are cream-colored. If a gray male and a yellow female, when mated, produce offspring approximately 3/8 of which are yellow, 3/8 gray, 1/8 cream, and 1/8 black, what are the genotypes of the two parents?
23. What are the genotypes of a yellow male rat and a black female that, when mated, produce 46 gray and 53 yellow offspring?
24. In Leghorn chickens colored feathers are due to a dominant gene, C; white feathers are due to its recessive allele, c. Another dominant gene, I, inhibits expression of color in birds with genotypes C/C or C/c. Consequently, both C/- I/- and c/c -/- are white. A colored rooster is mated with a white hen and produces many offspring, all colored. Give the genotypes of both parents and offspring.
25. If the dominant gene K is necessary for hearing, and the dominant gene M results in deafness no matter what other genes are present, what percentage of the offspring produced by the cross k/k M/m x K/k m/m will be deaf?
26. If a man with blood type B, one of whose parents had blood type O, marries a woman with blood type AB, what will be the theoretical percentage of their children with blood type B?
27. Both Mrs. Smith and Mrs. Jones had babies the same day in the same hospital. Mrs. Smith took home a baby girl, whom she named Shirley. Mrs. Jones took home a baby girl, whom she named Jane. Mrs. Jones began to suspect, however, that her child had been accidentally switched with the Smith baby in the nursery. Blood tests were made: Mr. Smith was type A, Mrs. Smith type B, Mr. Jones type A, Mrs. Jones type A, Shirley type O, and Jane type B. Had a mix-up occurred?
28. Suppose that gene b is sex-linked, recessive, and lethal. A man marries a woman who is heterozygous for this gene. If this couple had many normal children, what would be the predicted sex ratio of these children?
29. Red-green color blindness is inherited as a sex-linked recessive. If a color-blind woman marries a man who has normal vision, what would be the expected phenotypes of their children with reference to this character?
30. A man and his wife both have normal color vision, but a daughter has red-green color blindness, a sex-linked, recessive trait. The man sues his wife for divorce on grounds of infidelity. Can genetics provide evidence supporting his case?
31. It is exceedingly difficult to determine the sex of very young chickens, but it is easy to tell, by visual observation, whether or not they are barred. The barred pattern is inherited as a sex-linked dominant. Set up a cross allowing the sex of all chicks to be determined when they hatch. (Remember, chickens are BIRDS).
32. The diagram below shows three generations of the pedigree of deafness in a family. Black circles indicate deaf persons. An arrow on a circle indicates a male, a cross below a circle a female. State whether the condition of deafness in this family is inherited as:
- a dominant autosomal characteristic
 - a recessive autosomal characteristic
 - a sex-linked dominant characteristic
 - a sex-linked recessive characteristic



33. In *Drosophila melanogaster* there is a dominant gene for gray body color and another dominant gene for normal wings. The recessive alleles of these two genes result in black body color and vestigial wings respectively. Flies homozygous for gray body and normal wings were crossed with flies that had black bodies and vestigial wings. The F1 progeny were then test-crossed, with the following results:

Gray body, normal wings 236; Black body, vestigial wings 253
 Gray body, vestigial wings 50; Black body, normal wings 61

Would you say that these two genes are linked? If so, how many units apart are they on the chromosomes?

34. In rabbits a dominant gene produces spotted body color, and its recessive allele solid body color. Another dominant gene produces short hair, and its recessive allele long hair. Rabbits heterozygous for both characteristics were mated with homozygous recessive rabbits. The results of this cross were as follows:

Spotted, short hair 96; Solid, short hair 14
 Spotted, long hair 10; Solid long hair 80

Would you say that these two genes are linked? If so, how many units apart are they on the chromosomes?

35. In *Drosophila melanogaster* the genes for normal bristles and normal eye color are known to be about 20 units apart on the same chromosomes. Individuals homozygous dominant for these genes were mated with homozygous recessive individuals. The F1 progeny were then test-crossed. If there were 1,000 offspring from the test cross, how many of the offspring would you predict would show the crossover phenotypes?

36. The crossover frequency between linked genes A and B is 40%; between B and C is 20%; between C and D, 10%; between C and A, 20%; between D and B, 10%. What is the sequence of the genes on the chromosome?

From: <http://www.msu.edu/course/lbs/144/f99/geneticsprob.html>

37. What combination of alleles will show up in the gametes of an individual with the genotype

- a. RrJj
- b. RRjj
- c. RrJJ

38. Lactose is a sugar which is found in dairy products. Lactose intolerance is inherited as an autosomal dominant trait. People who have an allele for lactose intolerance cannot properly digest milk products. Paul is intolerant of lactose but his wife, Laura, is not. Additionally, Paul's mom Cathy, and brother, Mike, can eat lots of ice cream. Paul's dad, Scotty, cannot eat ice cream.

- a. Draw a pedigree of this family.
- b. What are Mike, Paul, Cathy, and Scotty's phenotype and genotype?
- c. Knowing Paul's genotype, what alleles can he pass on to his offspring?
- d. What is the probability that Paul and Laura will have a girl that is intolerant of lactose?

39. Two persons heterozygous for albinism marry. Albinism is a recessive trait in which the individual is unable to produce any pigment. Only the lady is able to curl her tongue, an ability she shares with her father but not with her

mother. If tongue curling is dominant, what is the probability that their first child will be an albino capable of tongue curling?

- P=pigment
- p=albino
- C=tongue curling
- c=no curling

40. Hemophilia is a sex-linked genetic disease that has plagued the royal houses of Europe since the time of Queen Victoria, who was a carrier. Her Granddaughter, Alexandria married Nicholas II, the last tsar of Imperial Russia. Nicholas was normal. Their son, Alexis, was afflicted with the disease. Alexis and his four sisters are all thought to have been killed at the outbreak of the Revolution of 1917. Based on probability

- a. all four sisters were not carriers of the hemophilia allele.
- b. all of the sisters had hemophilia.
- c. all of the sisters were carriers of hemophilia.
- d. one or more of the sisters may of had hemophilia.
- e. one or more of the sisters may have been a carrier of hemophilia.

41. Three babies are accidentally mixed up in a hospital. In order to find out which parents the babies go to, blood types are examined. The results are presented below.

Baby	Blood Type	Parents	Blood type
1	AB+	1	B+ and AB-
2	B+	3	AB+ and O+
3	O-	2	A+ and B+

Think carefully and assign the babies to their proper parents.

- a. Baby 1 to parents 1, baby 2 to parents 2, and baby 3 to parents 3.
- b. Baby 1 to parents 2, baby 2 to parents 1, and baby 3 to parents 3
- c. Baby 1 to parents 3, baby 2 to parents 1, and baby 3 to parents 1
- d. Baby 1 to parents 2, baby 2 to parents 3, and baby 3 to parents 1
- e. The babies are hopelessly mixed up since blood types cannot resolve the problem in this particular case.

From: <http://krupp.wcc.hawaii.edu/BIOL100/genetics/genetics1/GenProbI.htm>

42. In tomatoes the texture of the skin may be smooth or peach (hairy). The Ponderosa variety has fruits with smooth texture. The red peach variety has fruits with peach texture. Crosses between the two varieties produce all smooth fruits. Crosses between these smooth fruited F₁ plants produced 174 peach textured fruits and 520 smooth textured fruits. How are these skin textures inherited?

From: <http://krupp.wcc.hawaii.edu/BIOL100/genetics/genetics2/GenProbII.htm>

43. In turkeys a dominant gene R produces the familiar bronze color; its recessive allele r results in red. Another dominant gene H results in normal feathers; its recessive allele h produces feathers without webbing, so that they resemble tufts of hair. Two bronze turkeys with normal feathers were mated, and their offspring consisted of 8 bronze with normal feathers, three bronze with hairy feathers, two red with normal feathers, and one red with hairy feathers. What were the genotypes of the parents?

44. In horses black is dependent upon a dominant gene, B, and chestnut upon its recessive allele, b. The trotting gait is due to a dominant allele T, and the pacing gait to its recessive allele, t. If a homozygous black pacer is mated to a homozygous chestnut trotter, what will be the appearance of the F₁ generation? What would be the genotypes and phenotypes (and their expected ratios or percentages) of the offspring produced by a mating between an F₁ generation individual and a chestnut trotter?

51. Suppose that an allele, b , of a sex-linked gene is recessive and lethal. A man marries a woman who is heterozygous for this gene. If this couple had a large number of normal children, what would be the predicted sex ratio of these children (ratio of male children to female children)? (adapted from J.L. Gould and W.T. Keeton (1996). *Biological Science*. Sixth Edition. W.W. Norton & Company. New York. P. 443)

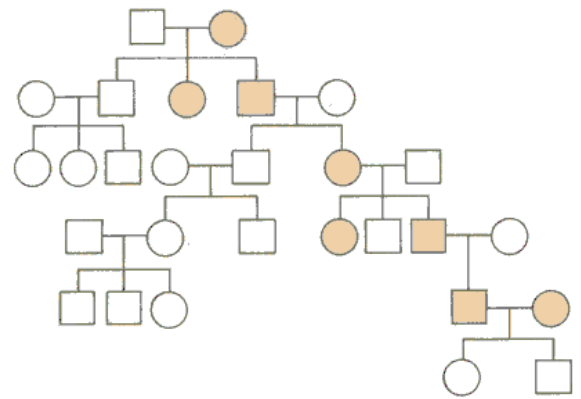
52. In *Drosophila melanogaster* there is a dominant allele for gray body color and a dominant allele of another gene for normal wings. The recessive alleles of these two genes result in black body color and vestigial wings, respectively. Flies homozygous for gray body and normal wings are crossed with flies that have black bodies and vestigial wings. The F_1 progeny are then crossed, with the following results

- Gray body, normal wings: 236
- Black body, vestigial wings: 253
- Gray body, vestigial wings: 50
- Black body, normal wings: 61

Would you say that these two genes are linked? If so, how many map units apart are they on the linkage map? (adapted from J.L. Gould and W.T. Keeton (1996). *Biological Science*. Sixth Edition. W.W. Norton & Company. New York. P. 443)

53. An afflicted woman marries an afflicted man. The allele causing the affliction is recessive to the wild type allele. What fraction of their children will be silent carriers? What fraction will be afflicted?

54. For the following pedigree, how does the afflicting allele impact on phenotype? (figure is from M.R Cummings (1988). *Human Heredity: Principles and Issues* West Publishing Company. New York. p. 113)



- i. it displays complete dominance
- ii. it is recessive to the non-afflicting allele otherwise found at the same loci
- iii. it displays epistasis
- iv. it displays pleiotropic effects
- v. it produces a tRNA product
- vi. it is a Mendelian ratio

55. If a husband and wife have four daughters. Under most circumstances, what is the probability that their fifth child will also be a girl? (adapted from G.T. Licata & W.H. Garnsey (1986). *A General Review of Biology* 2nd Edition. N & N Publishing, Middletown, NY, p. 119)

56. A male cat has short hair, a stubby tail, and extra toes. A female cat has long hair, a long tail, and extra toes. The genes and alleles are as follows:

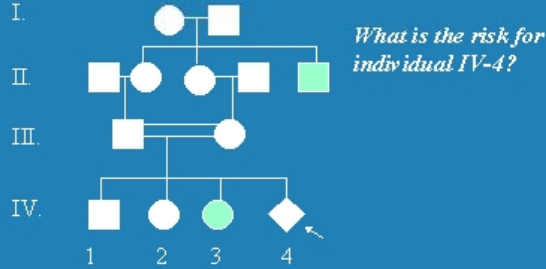
- L = short hair; l = long hair
- M = stubby tail; m = long tail
- P = extra toes; p = normal number of toes

The two cats have kittens. One kitten has long hair, a long tail, and no extra toes. Another has short hair, a stubby tail, and extra toes. The third kitten has short hair, a long tail, and no extra toes. What is the genotype of the father. (adapted from R. Lewis (1998). *Life* Third Edition. McGraw-Hill, Boston, Mass., p. 283)

57. The recombination frequency between linked genes A and B is 40%, between B and C is 20%, between C and D is 10%, between C and A is 20%, and between D and B is 10%. What is the sequence of the genes on the chromosome? (adapted from J.L. Gould and W.T. Keeton (1996). *Biological Science*. Sixth Edition. W.W. Norton & Company. New York. P. 443)

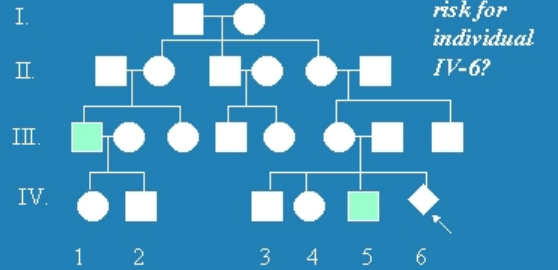
Pedigree Practice Problems

A. What is the mode of inheritance?



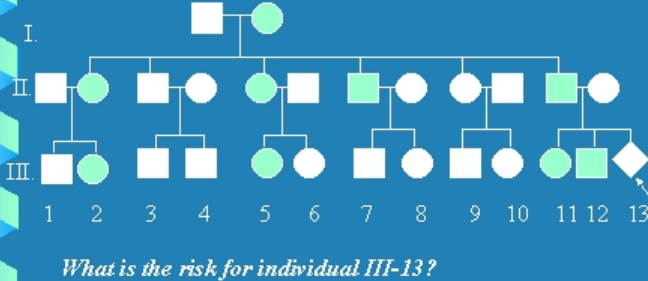
Pedigree Practice Problems

B. What is the mode of inheritance?



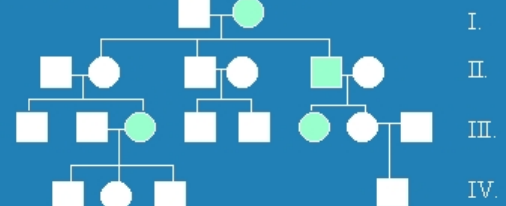
Pedigree Practice Problems

D. What is the mode of inheritance?



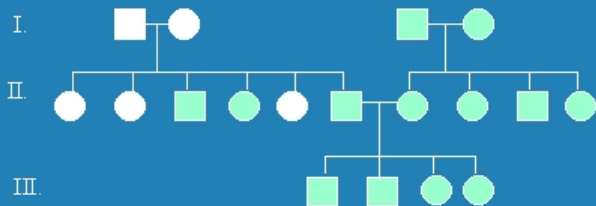
Pedigree Practice Problems

F. What is the mode of inheritance?



Pedigree Practice Problems

M. What is the mode of inheritance?



Answers to the Pedigree Practice Problems

- A. Autosomal recessive; risk is 1 in 4
- B. X-linked recessive; risk is 1 in 2 males or 1 in 4 any offspring
- C. Y-linked
- D. Autosomal dominant; risk is 1 in 2
- E. Mitochondrial
- F. Autosomal dominant with reduced penetrance
- G. X-linked recessive; inbreeding shows apparent male to male transmission
- H. Autosomal dominant with imprinting
- I. X-linked dominant; male lethal