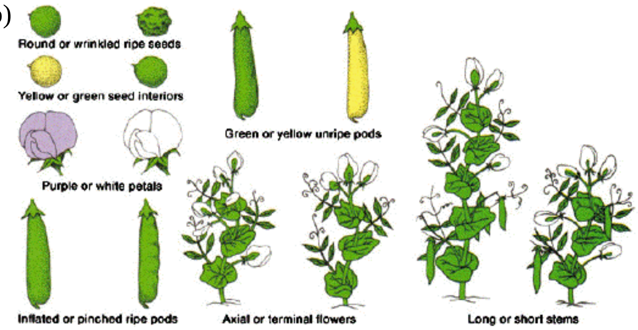
Genetics

Terminology

genetics – the study of heredity
h**eredity** – process by which genetic information is passed to next generation
gamete - a sex cell (sperm or egg) possessing half the full set of chromosomes. Is produced via meiosis.
genotype - genetic constitution of an individual using symbols such as BB, Bb, bb.
phenotype - the appearance of the individual with respect to a particular trait as produced by the genotype.
dominant - a form of a gene that suppresses expression of the other in the heterozygous condition.
recessive - a form of a gene that is hidden when occurring in heterozygous condition. Is expressed only when the determining gene is in the homozygous condition.

homozygous - having the identical two alleles (form of a gene) on homologous chromosomes. (BB or bb)
heterozygous - having different alleles on homologous chromosomes. (Bb)
P_1 - parent generation
F_1 – first offspring generations (filial)



A. Work of Mendel (Gregor Mendel 1856)

Mendel bred garden peas and studied the heredity of the following traits:
1) seed and pod shape.
2) plant height and bud location.
3) seed, pod, and petal color.

B. Example of Early Breeding Results

1) Cross of purebred tall plant with purebred short plant produced only tall offspring.
2) When two of the tall offspring from the above cross were bred, they produced both tall and short offspring in a 3:1 ratio.
Mendel set out to work out a mathematical model that could explain his findings.

C. Conclusions

1) Genes come in pairs
Each genetic characteristic is controlled by a pair of genes.
2) Law of Dominance
Whenever contrasting genes are found, one will be shown and the other hidden.
3) Law of Segregation
Genes are carried in pairs and separate during meiosis to be distributed into different sex cells.
4) Law of Random (Independent) Assortment
Separation of genes during meiosis occurs randomly.

Monohybrid Cross

Definition: cross that will produce offspring having contrasting genes for ***one*** characteristic.

Purebred cross of pea plants as Mendel performed. Given tall is dominant over short.

T = tall   t = short

P_1 phenotype:

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Hybrid cross of pea plants. (F_1 x F_1)

F_1 phenotype:

F_1 genotype:

Gametes:

F_2 genotype:

F_2 phenotype:

<u>Example Monohybrid Crosses</u>

Example 1: In garden peas, round seeds are dominant over wrinkled. A homozygous round plant is crossed with a homozygous wrinkled plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 2: In garden peas, yellow seeds are dominant over green. A heterozygous yellow seeded plant is crossed with a green seeded plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 3: In garden peas, deep roots are dominant over shallow. A heterozygous deep-rooted plant is crossed with another deep rooted plant, one of which parents had shallow roots.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 4: In garden peas, tall is dominant over short. A tall plant, one of which parents was short is crossed with a short plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

<u>Test Cross</u>

If you have a plant (for example tall plant) and you are not sure if it is a pure breed (TT or Tt). To find out you would perform a test cross. Cross it with a purebred recessive plant (tt).

P_1 phenotype: tall x short

P_1 genotype: T? x tt

TT x tt — Tt x tt

Gametes: T t — T,t t

F_1 genotype: All Tt

F_1 phenotype: **All Tall**

F_1 genotype: 1 Tt: 1 tt

F_1 phenotype: 1 tall : **1 short**

Therefore if the recessive phenotype shows up in the offspring of the test cross then you known the plant in question was heterozygous (Tt) if not it was homozygous (RR).

<u>Mendelism Modified</u>

After Mendel, geneticists found several exceptions to his laws. Recall his first 2 laws:

1) Genes come in pairs: Each genetic characteristic is controlled by a single pair of genes.

2) Law of Dominance: Whenever contrasting genes are found, one will be shown and the other hidden.

<u>Exception to 1st Law: Multiple Alleles</u>

When 3 or more pairs of genes at the **same location** on a chromosome are controlling a characteristic.

<u>Example</u>

Drosophila (fruit fly) - **hierarchy** of eye color, many forms of eye color possible because many genes are involved (even though each only contains two). A wine eyed fly (C^WC^I) is crossed with a homozygous apricot eyed fly.

red = C^R
wine = C^W
coral = C^{Co}
cherry = C^{CH}
apricot = C^A
Eosin = C^{Eo}
ivory = C^I
buff = C^{Bu}
ebony = C^{Eb}
white = C^r

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Exceptions to 2nd Law

A) Non-dominance or Incomplete dominance

One trait does not completely dominate the other resulting in a blending of the traits. Ie. brown and white gene = tan appearance
There are 2 options for symbolism for non-dominance or incomplete dominance.

Option 1: Using Superscript	Option 2: Using a dash mark (`) referred to as prime
Brown gene = $\mathbf{C^B}$	Brown gene = **C**
White gene = $\mathbf{C^W}$	White gene = **C`**

Incomplete Dominance Sample Problems

Example 1: In humans, straight hair is incompletely dominant over curly hair. What will be the genotype and phenotype of a cross between a wavy haired person and a straight haired person?

P_1 phenotype:

P_1 genotype:

gametes:

F_1 genotype:

F_1 phenotype:

Example 2: In Four O'clocks, red and white flowers are incompletely dominant and the heterozygote is pink. What will be the genotype and phenotype of a cross between a red and a white?

P_1 phenotype:

P_1 genotype:

gametes:

F_1 genotype:

F_1 phenotype:

B) Co-dominance

With **co-dominance** both traits are expressed. Co-dominance is sometimes seen in flowers, cattle, fowl, and humans. An example of co-dominance in cattle is a red bull and a white cow producing a roan calf that has intermingled red and white hair. A human example would be blood types. Here the A and B traits are co-dominant over O.

Blood Type	**Homozygous**	**Heterozygous**
A	I^AI^A	I^Ai
B	I^BI^B	I^Bi
AB	-------	I^AI^B
O	ii	-------

Example 1

A woman with type AB blood can have children of what blood type with a man who is homozygous for type A blood?

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

<u>Example 2</u>
Could a woman with type A blood and a man with type AB blood have a type O child?

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

<u>Sex Linked Genetics</u>

<u>A. Sex Determination</u>

Thomas Morgan worked with fruit flies and found that females and males differ by 1 chromosome and that males have 1 modified chromosome (the "Y" chromosome).

Autosomal Chromosomes - pairs of chromosomes, which **are identical** in males and females.
Sex Chromosomes - chromosomes, which are **not identical** in males and females (X and Y).

<u>Male</u> (XY)	**<u>Female</u>** (XX)
22 pairs of autosomal	22 pairs of autosomal
1 of each sex chromosome	pair of X sex chromosomes

What are the odds of one's first child being a boy? _____ The first two being boys? ________The first three being boys? _______

<u>B. Sex Linked Genes</u>

- Genes carried on the **X chromosome** (also called X-linked)
- If **sex linked recessive**, the trait (disease or disorder) **can be** hidden in females since they have another X chromosome (called carriers, do not show the disorder but pass it on).
- Affected males will always show the disorder since they only have one X chromosome. Human examples include hemophilia and colorblindness.
- If **sex linked dominant**, the trait (disease or disorder) **can not be** hidden in females. Affected males will always show the disorder since they only have one X chromosome.

<u>Sex Linked Sample Problem</u>

In fruit flies round wings is sex linked dominant over pointy wings. What phenotype and genotype would you expect from a cross between a heterozygous round wing female and a round winged male?

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Dihybrid Crosses
Definition: cross that will produce offspring having contrasting genes for ***two*** characteristics.

Example 1
In garden peas, round seeds are dominant over wrinkled and yellow seeds are dominant over green. A homozygous round yellow seeded plant is crossed with a homozygous wrinkled green seeded plant

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 2
In garden peas, tall is dominant over short and deep roots are dominant over shallow. A heterozygous tall shallow rooted plant is crossed with a homozygous tall and deep-rooted plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 3
In garden peas, tall is dominant over short and deep roots are dominant over shallow. Heterozygous tall shallow rooted plant is crossed with a short heterozygous deep rooted plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 4

In garden peas, tall is dominant over short and deep roots are dominant over shallow. A plant heterozygous for both traits is crossed with a homozygous tall and shallow rooted plant.

P_1 genotype:

Gametes:

F_1 genotype:

F_1 phenotype:

Example 5: In certain cats long hair is dominant over short hair and black fur is dominant over white fur. Cross two cats that are heterozygous for both traits.

P_1 genotype:

Modes of Inheritance

1. Straight Dominance

Example: Brown eyes vs Blue eyes

B = brown b = blue

BB x Bb

2. Multiple Alleles

red = C^{R}
wine = C^{W}
coral = C^{Co}
cherry = C^{CH}
apricot = C^{A} :
Eosin = C^{Eo}
ivory = C^{I}
buff = C^{Bu}
ebony = C^{Eb}
white = C^{r}

Example: $C^{Co} C^{Eb}$ x $C^{Eo} C^{Bu}$

3. Incomplete Dominance

Example: Red flowers vs White flowers

F^{R} = red F^{W} = white

$F^{R}F^{R}$ x $F^{R}F^{W}$

4. Co-Dominance

Example: Type A and B are co-dominant over O type blood

I^{A} = type A gene
I^{B} = type B gene
i = type O gene

$I^{A}I^{A}$ x $I^{B}i$

5. Sex-linked

Example: Normal color vision vs colour blindness

X^{N} = normal vision
X^{n} = colour blind

$X^{N}X^{n}$ x $X^{N}Y$

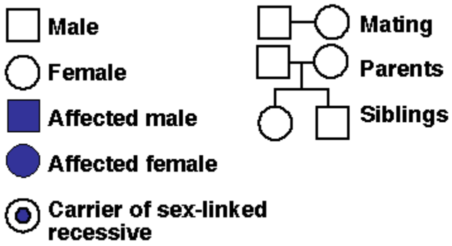
6. Dihybrid

Example: Plant height and seed color

T = tall t = short
Y = yellow y = green

TTYy x ttYy

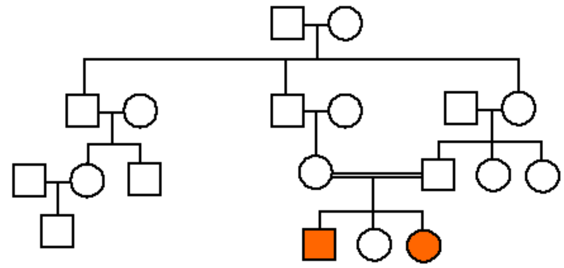
Pedigree Charts



A register recording a line of ancestors. The recorded purity of breed of an individual or strain. Is often shown in chart form. Symbols used in pedigree charts show to the left.

Autosomal Recessive Pedigree

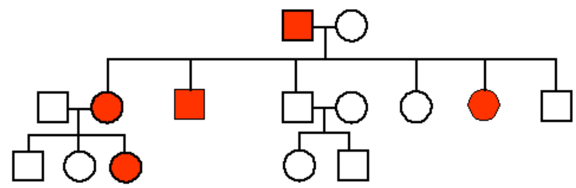
- **Autosomal**: Gene is on one of the autosomes (Chromosomes 1-22). Male and female offspring equally likely to inherit trait.
- **Recessive**: If neither parent has the characteristic phenotype (disease) displayed by the child, the trait is recessive.



Inheritance of an Autosomal Recessive Trait

Autosomal Dominant Pedigree

- **Autosomal**: Gene is on one of the autosomes (Chromosomes 1-22). Male and female offspring equally likely to inherit trait.
- **Dominant**: Affected individuals appear in every generation.
- A trait that appears in successive generations is normally due to a dominant allele.

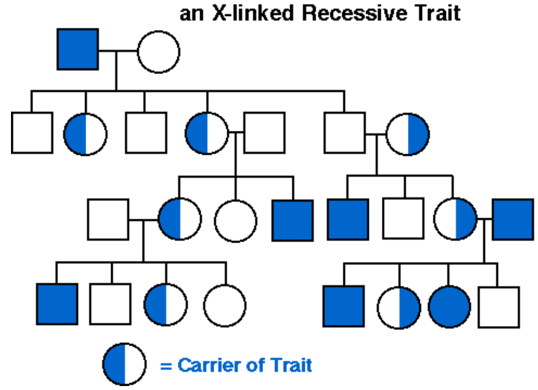


Inheritance of an Autosomal Dominant Trait
(Example: Huntington's Disease)

Sex-Linked Pedigree

- Most X-linked traits are recessive.
- The trait is more often seen in males. If X-linked recessive, heterozygous females are "carriers". If X-linked dominant heterozygous females affected.
- Inheritance of red-green color blindness, an X-linked, recessive trait:

Inheritance of Red-Green Color Blindness:
an X-linked Recessive Trait



Human Pedigree Charts

A pedigree is a table or chart recording a line of ancestors or genealogy, either of persons or of animals. A genealogy is an account of the descent of a person or family traced through a series of generations, usually from the first known ancestor. To analyze a chart, follow the two steps outlined below.

Step 1: Determining Mode of Inheritance

More than one pedigree may be necessary to determine the exact mode of inheritance, but in our examples only one is provided. Determining the mode has two parts.

Part A: Autosomal, Sex-linked or Holandric

Autosomal – the trait is on 1 of the 22 pairs of autosomal chromosomes shared by males and females.
Sex-linked – the trait is on the X chromosome (males have only 1 and females have 2).
Holandric – the trait is on the Y chromosome (males only).

Study the number of **affected** males and females on the chart to determine if the trait is Autosomal, Sex-linked or Holandric.

If the number of affected males and females is **approximately equal** the trait is likely **Autosomal**.
If the number of affected males and females is **not approximately equal** the trait is likely **Sex-linked**.
If **only males** and **all** of their sons are affected the trait is **Holandric**.

Part B: Dominant or Recessive

Dominant – the trait (gene) that suppresses expression of the other in the heterozygous condition. The dominant gene can therefore not be present without expressing itself in the phenotype. (ie. Brown eyes)
Recessive – producing no phenotypic effect when occurring in heterozygous condition with a contrasting trait (gene). Expressed only when in the homozygous condition. (ie. Blue eyes)

Study whether the trait appears in every generation on the chart to determine whether the trait is dominant or recessive.

If you **can not** find one example where an individual is affected and neither parent is affected the trait is likely **Dominant**.
If you **can** find one example where an individual is affected and neither parent is affected the trait is **Recessive**.

The following key will be provided for your assistance during the exam.

Auto – Dom	Males ≈ Females and does **not** skip generation.
Auto – Rec	Males ≈ Females and does skip generation.
X – Dom	Females > Males and does **not** skip generation (affected males transmit trait to all daughters and no sons).
X – Rec	Males > Females and does skip generation (trait never transmitted directly from father to son).
Holandric	All affected males pass to all sons.

Step 2: Defining Variables

You can choose any variable to represent the trait, but since we are not dealing with specific traits such as color-blindness, I will use the letter B to represent the "bad" trait.

Auto – Dom	let "B" represent the bad gene and "b" represent the good gene
Auto – Rec	let "b" represent the bad gene and "B" represent the good gene
X – Dom	let "X^B" represent the bad gene and "X^b" represent the good gene
X – Rec	let "X^b" represent the bad gene and "X^B" represent the good gene
Holandric	let Y` (Y prime) represent the bad gene and "Y" represent the good gene

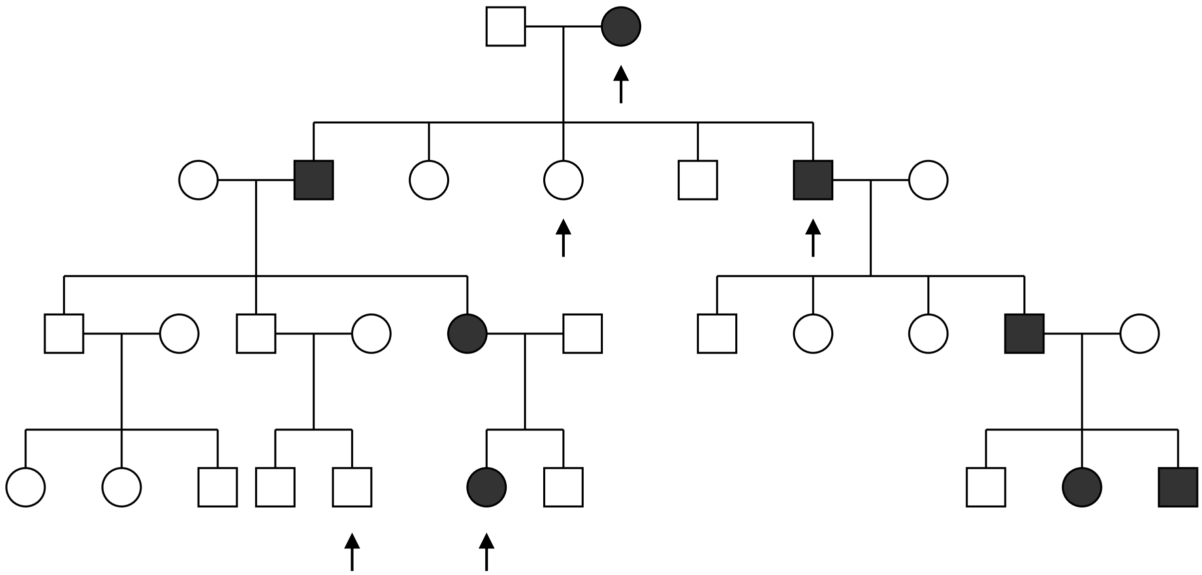
Assignment

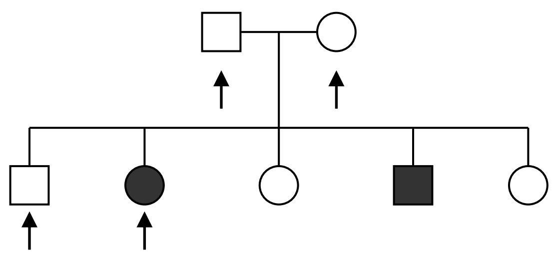
1. For the 12 practice pedigree charts provided:
a. Determine the probable mode of inheritance.
b. Indicate the genotype of the individuals marked with an arrow.
2. Draw a **simple** pedigree chart that represents each of the following.
a) an autosomal dominant trait b) an autosomal recessive trait c) a sex-linked dominant trait
d) a sex-linked recessive trait e) a holandric trait

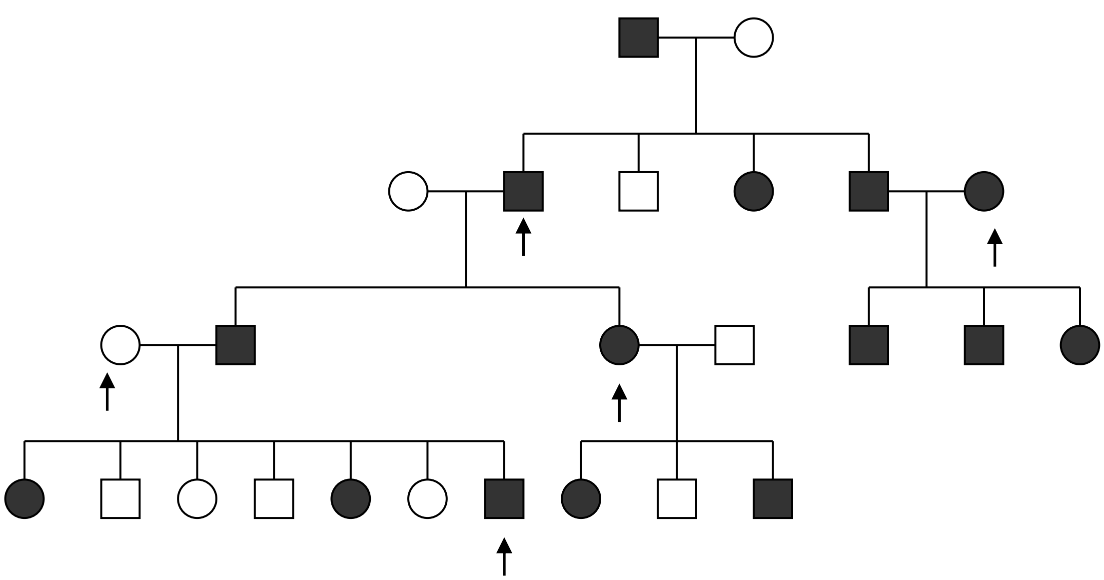
Key for Practice Pedigree Charts

1) Auto Recessive 2) X Recessive 3) X Dominant 4) Auto Dominant 5) Holandric 6) Auto Recessive 7) X-Dominant
8) Auto Recessive 9) X Recessive 10) Holandric 11) Auto Dominant 12) X Dominant

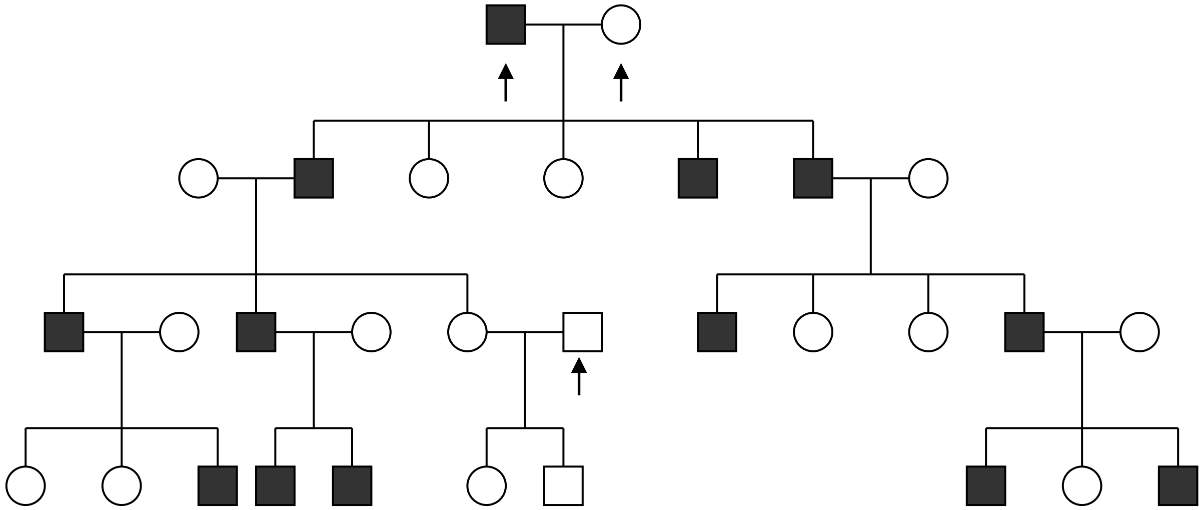
Example Pedigree Charts (page 1)

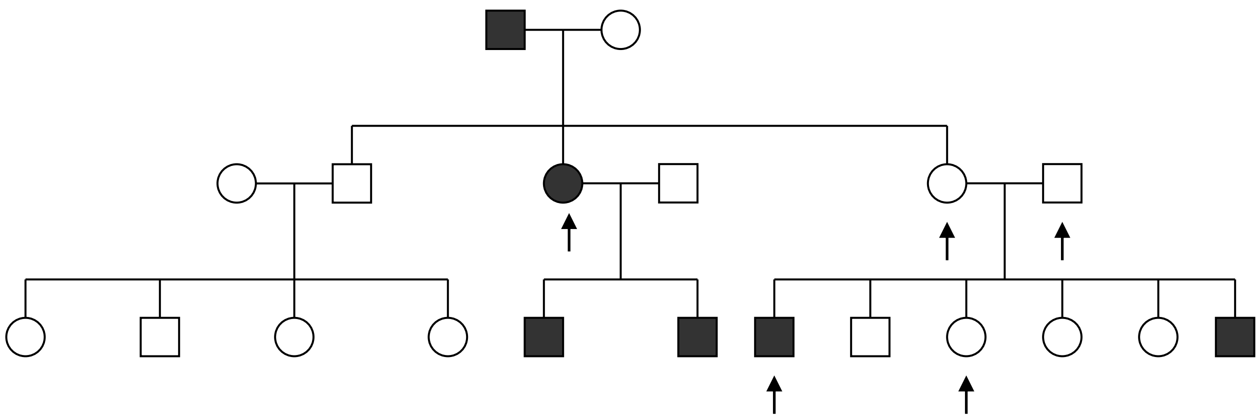


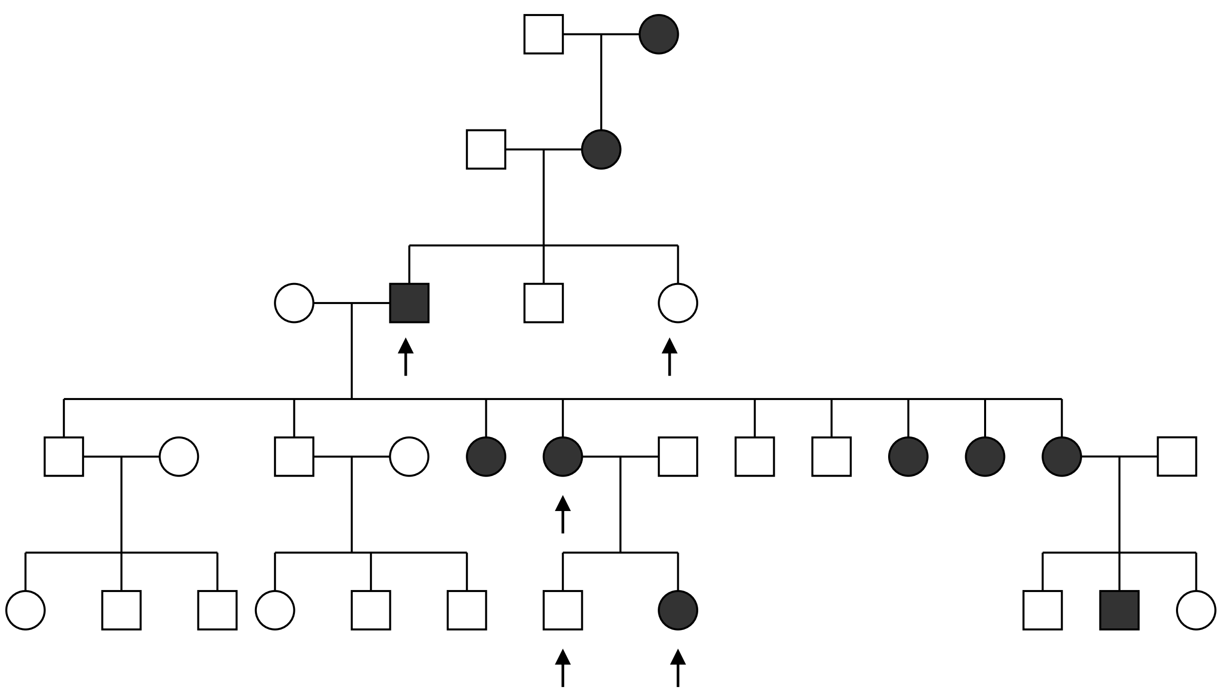




Example Pedigree Charts (page 2)







Monohybrid Questions

1. In peas, yellow pod color is dominant to green pod color. Give the results of the following crosses.
a. Heterozygous yellow x homozygous recessive green
b. homozygous yellow x heterozygous yellow
c. Homozygous yellow x green

2. In humans, dimples in the chin are dominant to no dimples in the chin. Cross a homozygous recessive non-dimpled person with a heterozygous dimpled person. What are the chances of this couple having a child with dimples?

3. In humans, brown hair is dominant to blonde hair. Cross a homozygous dominant brown hair person with a homozygous recessive blonde hair person.

4. In pea plants, round seeds are dominant to wrinkled seeds. Cross a heterozygous round seed plant with a homozygous dominant round seed plant.

5. In humans Blue eye color is recessive to brown.
a) Could two brown eyed parents have a blue eyed child? Show your work.
b) Could two blue eyed parents have a brown eyed child? Show your work.

6. In summer squash, white fruit color is dominant to yellow fruit color.
a) What would the genotype and phenotype be for the F_1 generation if the parental cross was homozygous dominant white and homozygous recessive yellow?
b) What would the genotype and phenotype be for the F_2 generation if you crossed two F_1 individuals from the above problem?

7. Albinism, the total lack of skin pigment, is due to a recessive gene. A man and a woman plan to marry and wish to know the probability of their having any albino children.
a) What could you tell them if both are normally pigmented, but each has one albino parent?
b) What could you tell them if the man is albino, the woman is normal, but her father is an albino?
c) What could you tell them if the man is albino and the girl's family includes no albinos?

8. In humans Blue eye color is recessive to brown. A blue eyed man, both of whose parents were brown eyed, married a brown eyed woman whose father was blue eyed. What are the chances of this couple having a blue eyed child?

9.In certain trees, smooth bark is dominant over wrinkled. Cross two trees that are heterozygous for smooth bark. If there are 100 offspring produced, how many would you expect to have wrinkled bark?

10.In Mountain Boomers, the genes for length of tail exhibit "incomplete" dominance. Cross a homozygous Long-tailed and a homozygous Short-tailed Mountain Boomer.

11.Height in pea plants is determined by the dominant tall gene and the recessive short gene. Cross a homozygous tall pea plant with a dwarf pea plant to determine the probability of producing a tall plant.

12.Height in pea plants is determined by the dominant tall gene and the recessive short gene. Cross 2 heterozygous tall plants. What is the probability of producing a dwarf plant?

13.Hazel is heterozygous for type B blood and Elijah has type O blood. If they have children, what is the probability that they will have;
a) a type A child? b) a type B child? c) a type AB child? d) a type O child

14.The ability to taste the chemical PTC is determined by a single gene in humans with the ability to taste given by the dominant allele T and inability to taste by the recessive allele t. Try some PTC for yourself to determine if you possess the tasting gene. Suppose two heterozygous tasters (Tt) have a large family.
a. Predict the proportion of their children who will be tasters and non-tasters. Use a Punnett square to illustrate how you make these predictions.
b. What is the likelihood that their first child will be a taster? What is the likelihood that their fourth child will be a taster?

15.A rooster with grey feathers is mated with a hen of the same phenotype. Among their offspring 15 chicks are grey, 6 are black and 8 are white.
a. What is the simplest explanation for the inheritance of these colors in chickens?
b. What offspring would you expect from the mating of a grey rooster and a black hen?

16.In a certain plant, blue flower color is dominant to white. You have a blue flowered plant.
a. What do you know about the phenotype and genotype of the plant?
b. Explain how you would figure out the complete genotype of the plant.
c. Show the P_1 Geno for the test cross.

17.Woodrats are medium sized rodents with lots of interesting behaviours. You may know of them as packrats. The trait of bringing home shiny objects is dominant to the trait of carrying home only dull objects. Suppose two heterozygous individuals are crossed. How many of each genotype would be expected if 8 offspring were produced?

18.The common grackle is a species of robin-sized blackbirds that are fairly common (hence the name) over most of the United States. Suppose that long tails were incompletely dominant to short tails in these birds. A female medium-tailed grackle mates with a male grackle who had one parent with a long tail and one parent with a short tail. Show the cross.

19.The ability to curl your tongue up on the sides is dominant to not being able to roll your tongue.
a) What is your phenotype and genotype with respect to this trait?
b) A woman who can roll her tongue marries a man who cannot. Their first child has his father's phenotype. What are the genotypes of the mother, father, and child?

20.In Northeast Kansas there is a creature know as a wildcat. It comes in three colors, blue, red, and purple. This trait is controlled by a gene with incomplete dominance. A heterozygous individual is purple. What would be the genotypes and phenotypes of the offspring if a blue wildcat were crossed with a purple one?

21.With the lubber grasshopper red stripes are co dominant with yellow.
a) What will be the phenotypic and genotypic ratio of a cross of two grasshoppers, both with red and yellow stripes?
b) What genotypes and phenotypes would be produced by crossing a grasshopper with both color stripes and one with yellow stripes?

22.A naturalist visiting an island in the middle of a large lake observes a species of small bird with three distinct types of beaks. Those with short, crushing beaks consume hard shelled nuts, those with long, delicate beaks pick the seeds from pine cones, and those with intermediate beaks, consume both types of seeds though they are not as good at either. Assume that this difference in beak morphology is the result of incomplete dominance. Cross a bird with a short, crushing beak with one with an intermediate beak.

23.In pea plants, spherical seeds are dominant to dented seeds. In a genetic cross of two plants that are heterozygous for the seed shape trait, what fraction of the offspring should have spherical seeds?

24. If yellow is dominant over green, to identify the genotype of yellow-seeded pea plants as either homozygous dominant or heterozygous, you could do a test cross with a plant of genotype _______.

25.A test cross is used to determine if the genotype of a plant with the dominant phenotype is homozygous or heterozygous. If the unknown is homozygous, all of the offspring of the test cross have the __________ phenotype. If any of the offspring show the have the __________ phenotype the unknown is heterozygous.

26.A genetic cross of snapdragons with red flowers with white flowers resulted in offspring that all had pink flowers. When the F1 plants were self-pollinated, the resulting F2-generation plants had a phenotypic ratio of 1 red: 2 pink: 1 white. Show the second cross.

27.Human blood type is determined by co-dominant alleles. A woman with type A blood and a man with type B blood could potentially have offspring with which blood types?

28. Human blood type is determined by co-dominant alleles. What are the possible blood types for a cross between a type AB and type O?

29. Human blood type is determined by co-dominant alleles. What are the possible blood types for a cross between two type AB people?.

30. Human blood type is determined by co-dominant alleles. What are the possible blood types for a cross between a homozygous type A and a heterozygous type B?

31. Human blood type is determined by co-dominant alleles. A boy has type A blood and his sister has homozygous recessive blood. The father has type B blood. What are the blood types and genotypes of the kids and there parents including their mother.

32.A cross between a white-fruited and a yellow-fruited squash plant produces all white plants. If two of the white offspring are crossed together, what will be the appearance of their offspring?

33.In guinea pigs, rough coat is dominant over smooth. If a homozygous rough-coated animal is crossed with a smooth one, what will be the phenotype of the F_1?

34.In four o'clocks, red & white flowers are incompletely dominant and the heterozygote is pink.
A. Cross a red-flowered four-o'clock plant with a white-flowered one.
B. Cross an F1 with an F1.
C. Cross an F1 with its red parent.

35.In Andalusian chickens, the heterozygous condition of the alleles for black feathers and white feathers is grey. What offspring will a grey Andalusian hen have if bred to roosters with the following feather colors:
A. black rooster x grey hen
B. grey rooster x grey hen
C. white rooster x grey hen

36.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 was type B, Mr. Jones was type A, Mrs. Jones was type A, Shirley was type O, and Jane was type B. Had a mix-up occurred?

Monohybrid Questions KEY

1a. Genotype 1Yy:1yy Phenotype 1 yellow: 1 green b. Genotype 1YY:1Yy Phenotype all yellow
c. Genotype All Yy Phenotype All yellow
2. Genotype 1Dd:1dd Phenotype 1 dimpled:1 no dimples
3.Genotype all Bb Phenotype all brown
4. Genotype 1RR:1Rr Phenotype all round
5. a) Yes b) No
6. a) Genotype all Ww Phenotype all white b) Genotype 1WW:2Ww:1ww Phenotype 3 white:1 yellow
7. a) They both are heterozygous Nn x Nn, therefore 1/4 or 25% chance of albino offspring
b) 50% chance of albino offspring (Man nn woman Nn)
c) No chance of albino offspring
8. 50% - man bb, his parents Bb and Bb, woman Bb, her father bb
9. 25
10.All have medium length tails.
11. 100% of F_1 will be tall.
12. 1 in 4 or 1/4 or 25% or 0.25
13. a) 0% b) 50 % c) 0% d) 50%
14. a. ¼ TT + ½ Tt = ¾ tasters ¼ tt = ¼ non-tasters
b. 1st child-- ¾ 4th child-- 3/4 (each child is independent)
c. 1/4 for each child; 1/4 x 1/4 x 1/4 = 1/64 that all three will be non-tasters
15. a. incomplete dominance of black over white; heterozygotes are grey
b. the rooster would be C^BC^b and the hen C^BC^B (C^B = black, C^b= white) half the offspring would be C^BC^B (black) and half C^BC^b (grey)
16. a. its blue and can be either BB or Bb b. do a test cross c. P_1 geno: B? x bb
17. 2SS:4Ss:2ss
18. $1T^LT^L:2T^LT^S:1T^ST^S$ 1 long: 2 medium: 1 short
19. Mother Tt, father tt, child tt
20. $1C^BC^B:C^BC^R$ 1 blue: 1 purple
21. a) phenotype: 1 red:2 red and yellow:1 yellowgenotype: 1 S^RS^R:2 S^RS^r:1 S^RS^r
b) 1 S^RS^r:1 S^rS^r 1 red and yellow:1 yellow
22.1 intermediate: 1 short
23.3/4 of the offspring
24. yy
25. dominant, recessive The test cross was invented by Mendel to determine the genotype of plants displaying the dominant phenotype.
26. P_1 geno: F^RF^W x F^RF^W
27. All 4 blood types.
28. 1A:1B
29. 1A:2AB:1B
30. 1A:1AB
31. Dad I^Bi, Mom I^Ai, Son I^Ai, Daughter ii
32. Parents = WW x ww Offspring = Ww (white). The white parent must be homozygous in order to produce all white offspring in this cross (which is a test cross). Now cross the white offspring = Ww x Ww to get = WW, Ww, Ww, ww and their appearance is 3 white : 1 yellow
33.A. Parental = RR x rr F1 = Rr, rough
34. a) R'R' X RR: Gametes = R' and R; Offspring = RR' and pink
b) RR' X RR': Gametes = R, R' and R, R'; Offspring = 1/4 RR (red), 1/2 RR' (pink), and 1/4 R'R' (white)
c) RR' X RR: Gametes = R, R' and R; Offspring = 1/2 RR (red) and 1/2 RR' (pink).d) R'R' X R'R: gametes = R' and R', R; Offspring = 1/2 R'R' (white) and 1/2 RR' (pink)
35. (A) black rooster BB x grey hen BB' offspring = 1/2 BB (black and 1/2 BB' (grey)
(B) grey rooster BB' x grey hen BB' offspring = 1/4 BB (black), 1/2 BB' (grey), and 1/4 B'B' (white)
(C) white rooster B'B' x grey hen BB' Offspring = 1/2 BB' (grey) and 1/2 B'B' (white)
36. The babies were switched.

Sex Linked Problems

1. In fruit flies, red eyes are dominant, and **X**-linked. A white-eyed female fruit fly (X^rX^r) is crossed with a red-eyed male (X^RY). What are the expected phenotypes of the offspring?
2. In a cross between a pure bred, red-eyed female fruit fly and a white-eyed male, what percent of the **male** offspring will have white eyes? (white eyes are **X**-linked, recessive)
3. Hemophilia is a sex-linked trait where X^H gives normal blood clotting and is dominant to the hemophilia allele X^h. What will be the results of mating between a normal (non-carrier) female and a hemophilac male?
4. Red-green color blindness (c) is inherited as a sex-linked recessive. If a color-blind woman marries a man who has normal vision (C), what would be the expected genotypes and phenotypes of their children with reference to this character?
5. A human female "carrier" who is heterozygous for the recessive, sex-linked trait causing red-green color blindness, marries a normal male. What proportion of their **male** progeny will have red-green color blindness?
6. 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?
7. Women have sex chromosomes of **XX**, and men have sex chromosomes of **XY**.
Which of a man's grandparents could be the source of any of the genes on his **Y**-chromosome?
A. Father's Mother.
B. Mother's Father.
C. Father's Father.
D. Mother's Mother, Mother's Father, and Father's Mother.
E. Mother's Mother.
8. Women have sex chromosomes of **XX**, and men have sex chromosomes of **XY**.
Which of a women's grandparents could **not** be the source of any of the genes on either of her **X**-chromosomes?
A. Mother's Father.
B. Father's Mother.
C. Mother's Mother.
D. Father's Father.
E. Mother's Mother and Mother's Father.
9. A couple has three girls in a row.
a) What are the odds that the 4th child will also be a girl?
b) What are the odds that the 5th child will also be a girl?
c) What are the odds of a couple having 5 girls in a row? (God help that father)
10. Hemophilia is a sex-linked trait where X^H gives normal blood clotting and is dominant to the hemophilia allele X^h.
a. Give the genotypes of 1) a woman with normal blood clotting whose father had hemophilia and 2) a normal man whose father had hemophilia.
b. What is the probability that a mating between these two individuals will produce a child, regardless of sex, that has hemophilia?
c. If this couple has a daughter, what is the probability that the daughter will be a carrier of the hemophilia trait? What is the probability a daughter would have hemophilia?
d. If this couple has a son, what is the probability he will have hemophilia?

<u>Sex Linked Problems</u> <u>KEY</u>

1. A white-eyed female fruit fly is crossed with a red-eyed male. Red eyes are dominant, and **X**-linked. What are the expected phenotypes of the offspring?
All of the females are red-eyed and heterozygous. All of the males are white-eyed.

2. In a cross between a pure bred, red-eyed female fruit fly and a white-eyed male, what percent of the **male** offspring will have white eyes? (white eyes are **X**-linked, recessive)
0%
All of the males and all of the females are red-eyed.

3. Hemophilia in humans is due to an **X**-chromosome mutation. What will be the results of mating between a normal (non-carrier) female and a hemophilac male?
all sons are normal and all daughters are carriers.

Daughters inherit a normal allele from their mother and the hemophilia allele from their father. Sons inherit the normal allele from their mother.

4. Red-green color blindness (c) is inherited as a sex-linked recessive. If a color-blind woman marries a man who has normal vision (C), what would be the expected genotypes and phenotypes of their children with reference to this character?
genotypes: 1 X^CX^c : 1 X^cY phenotype: all sons are color blind, all daughters are carriers but have normal vision.

5. A human female "carrier" who is heterozygous for the recessive, sex-linked trait causing red-green color blindness, marries a normal male. What proportion of their **male** progeny will have red-green color blindness?
50%
Half the sons would be expected to inherit the allele from their mother and be afflicted because they are hemizygous. Half the daughters would be carriers like their mothers.

6. 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?
Yes it can.

7. Women have sex chromosomes of **XX**, and men have sex chromosomes of **XY**.
Which of a man's grandparents could be the source of any of the genes on his **Y**-chromosome?
A. Father's Mother.
B. Mother's Father.
C. Father's Father.
D. Mother's Mother, Mother's Father, and Father's Mother.
E. Mother's Mother.

8. Women have sex chromosomes of **XX**, and men have sex chromosomes of **XY**.
Which of a women's grandparents could **not** be the source of any of the genes on either of her **X**-chromosomes?
A. Mother's Father.
B. Father's Mother.
C. Mother's Mother.
D. Father's Father.
E. Mother's Mother and Mother's Father.

9. A couple has three girls in a row.
a) What are the odds that the 4th child will also be a girl? **1/2**
b) What are the odds that the 5th child will also be a girl? **1/2**
c) What are the odds of a couple having 5 girls in a row? (God help that father) **1/32**

10. Hemophilia is a sex-linked trait where X^H gives normal blood clotting and is dominant to the hemophilia allele X^h.
a. Give the genotypes of 1) a woman with normal blood clotting whose father had hemophilia and 2) a normal man whose father had hemophilia.
1) the woman has normal clotting so she has one X^H but she got X^h from her father
2) the man is X^HY since he got the Y from his father and he is normal so must be X^H
b. What is the probability that a mating between these two individuals will produce a child, regardless of sex, that has hemophilia?
each child has a 1/2 chance of being male and males have a 1/2 chance of being affected; so 1/4 chance of a child with hemophilia
c. If this couple has a daughter, what is the probability that the daughter will be a carrier of the hemophilia trait?
1/2 chance of being a carrier
What is the probability a daughter would have hemophilia?
0 chance that a daughter would have hemophilia
d. If this couple has a son, what is the probability he will have hemophilia?
1/2 chance

Dihybrid Questions

For each problem draw the Punnett Square if needed, and answer the questions.

1. In certain peas, S is the allele for the dominant spherical shape characteristic; s is the allele for the recessive dented shape characteristic. Y is the allele for the dominant yellow color characteristic; y is the allele for the recessive green color characteristic. For each of the following write the genotype of the individual and list the gametes they can produce.

a) homozygous dominant for both traits
b) homozygous recessive for both traits
c) dented heterozygous yellow
d) heterozygous spherical green
e) heterozygous for both traits

2. In peas round seed is dominant (R) over wrinkled (r) and tall plant (T) is dominant over short plants (t). What will be the genotype and phenotype of the following crosses.

a) RRTT x RRTt b) RRTt x RRTt c) RrTt x RrTt
d) In the cross between a pure bred round seeded tall plant and a wrinkled seeded short plant.

3. In a dihybrid cross, AaBb x AaBb, what fraction of the offspring will be homozygous for both recessive traits?

4. Following a SsYy x SsYy cross, what fraction of the offspring are predicted to have a genotype that is heterozygous for both characteristics?

5. In a dihybrid cross, SsYy x SsYy, what fraction of the offspring will be homozygous for both traits?

6. 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 phenotypic ratios for the results of each of the following crosses:

A. TtSs X TtSs B. Ttss X ttss C. ttSs X Ttss D. TTss X ttSS

7. In certain bacteria, an oval shape is dominant over round and thick cell walls are dominant over thin. Cross a heterozygous oval, thick cell walled bacteria with a round, thin cell walled bacteria. Describe the genotype and phenotype of the offspring.

8. Cross a completely heterozygous round/yellow seeded plant with a completely homozygous round/green seeded plant. Also determine the probability of obtaining a round/yellow seeded plant in the offspring.

R = round seeds, r = wrinkled seeds
Y = yellow seeds, y = green seeds

9. In pepper plants, green (G) fruit color is dominant to red (g) and round (R) fruit shape is dominant to square (r) fruit shape. These two genes are located on different chromosomes.

a. What gamete types will be produced by a heterozygous green, round plant?
b. If two such heterozygous plants are crossed, what phenotypes will be seen in the offspring and in what proportions?

10. About 70% of Americans perceive a bitter taste from the chemical phenylthiocarbamide (PTC). The ability to taste this chemical results from a dominant allele (T) and not being able to taste PTC is the result of having two recessive alleles (t). Albinism is also a single locus trait with normal pigment being dominant (A) and the lack of pigment being recessive (a). A normally pigmented woman who cannot taste PTC has a father who is an albino taster. She marries a homozygous , normally pigmented man who is a taster but who has a mother that does not taste PTC.

a) What are the genotypes of the possible children?
b) What percentage of the children will be albinos?
c) What percentage of the children will be non-tasters of PTC?

11. Which of the following genetic crosses would be predicted to give a phenotypic ratio of 9:3:3:1?

A. SSYY x ssyy B. SsYY x SSYy C. SsYy x SsYy D. SSyy x ssYY E. ssYY x ssyy

12. Which of the following genotypes would you not expect to find among the offspring of a SsYy x ssyy test cross:

A. ssyy B. SsYy C. Ssyy D. ssYy E. SsYY

13. In Mendel's experiments, the spherical seed character (SS) is completely dominant over the dented seed character (ss). If the characters for height were incompletely dominant, such that TT are tall, Tt are intermediate and tt are short, what would be the phenotypes resulting from crossing a spherical-seeded, short (SStt) plant to a dented-seeded, tall (ssTT) plant?

14. Two unlinked loci effect mouse hair color. **CC** or **Cc** mice are agouti. "Agouti" refers to a dark brown to black hair that has a lighter tip, either silver, tan, yellow or orange. Many mammals have agouti hair color: rabbits and hares, raccoons, bears, miniature schnauzers. Mice with genotype **cc** are albino because all pigment production and deposition of pigment in hair is blocked. At the second locus, the **B** allele (black agouti coat) is dominant to the **b** allele (brown agouti coat). A mouse with a black agouti coat is mated with an albino mouse of genotype **bbcc**. Half of the offspring are albino, one quarter are black agouti, and one quarter are brown agouti. What is the genotype of the black agouti parent?

15. Two unlinked loci effect mouse hair color. **AA** or **Aa** mice are agouti. Mice with genotype **aa** are albino because all pigment production is blocked, regardless of the phenotype at the second locus. At the second locus, the **B** allele (also coding for agouti coat) is dominant to the **b** allele (black coat) which is dominant to the allele at the first locus. For example A_bb would be black and aa_ _ would be albino and A_ B _ would be agouti. What would be the phenotypic result of a cross between two agouti mice of genotype AaBb?

16. In summer squash, white fruit (W) is dominant over yellow (w); and "disk" fruit shape (D) is dominant over "sphere" shape (d).

A. In a cross between a squash plant homozygous for yellow fruit color and disk fruit shape and one homozygous for white fruit color and sphere fruit shape, what will be the appearance, as to color and shape of fruit, of the F1?

B. What will be the appearance, as to color and shape of fruit of the cross WwDd x WWdd.

17. In guinea pigs, rough coat (R) is dominant over smooth coat (r); and black coat (B) is dominant over white (b). Cross a homozygous rough, black animal with a smooth, white one.

A. What will be the appearance of the F1?

B. What will be the appearance of the F2?

18. In humans, assume that brown eyes (B) are dominant to blue (b); and right-handedness (R) to left-handedness (r). A right-handed, blue-eyed man whose father was left-handed marries a left-handed, brown-eyed woman from a family in which all the members have been brown-eyed for several generations. What offspring may be expected from this marriage as to the two traits mentioned?

19. A brown-eyed, right-handed man marries a blue-eyed, right-handed woman. Their first child is blue-eyed and left-handed. If other children are born to this couple, what will probably be their appearance as to these two traits?

20. A right-handed, blue-eyed man marries a right-handed, brown-eyed woman. They have two children, one left-handed and brown-eyed and the other right-handed and blue-eyed. By a later marriage with another woman who is also right-handed and brown-eyed, this man has nine children, all of whom are right-handed and brown-eyed. What are the genotypes of this man and his two wives?

21. In guinea pigs, black coat color is dominant over white, short hair is dominant over long, and rough coat is dominant over smooth. Cross a guinea pigs that is heterozygous for all three traits with a white, heterozygous short-haired, smooth coat guinea pig.

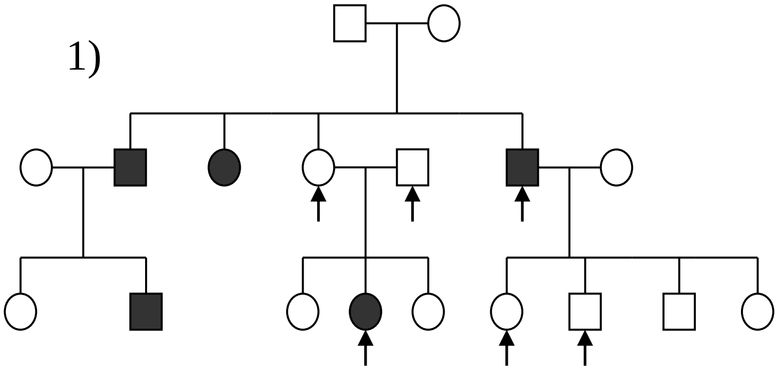
Dihybrid Answers
1. a) SSYY Gametes: SY
b) ssyy Gametes sy
c) ssYy Gametes: sY,sy
d) Ssyy Gametes Sy,sy
e) SsYy Gametes SY,Sy,sY,sy
2.
a) geno: 1 RRTT: 1 RRTt phono: all tall and round
b) geno: 1 RRTT :2 RRTt : 1 RRtt Pheno: 3 round tall: 1 round short
c) geno: 1 RRTT:2RRTt:1RRtt:2RrTT:4RrTt:1rrTT:2Rrtt:2rrTt:1rrtt
pheno: 9 round and tall:3 round and short: 3 wrinkled and tall: 1 wrinkled and short
d) geno: all RrTt pheno: all round and tall

3. 1/16
1/4 of the gametes of each parent will be ab. The fraction of the offspring homozygous for both recessive traits will be 1/4 times 1/4, or 1/16.
4. 4/16
Four out of 16 possible combinations of alleles yield the SsYy genotype. They are:
SY and sy
sY and Sy
Sy and sY
sy and SY
5. 1/4
There are four different genotypes that are homozygous for both traits. These are SSYY, SSyy, ssYY, and ssyy
6. A. TtSs X TtSs
9/16 tall smooth; 3/16 tall wrinkled; 3/16 short smooth; 1/16 short wrinkled
B. Ttss X ttss
1/2 tall wrinkled; 1/2 short wrinkled
C. ttSs X Ttss
1/4 tall smooth; 1/4 short smooth; 1/4 tall wrinkled; 1/4 short wrinkled
D. TTss X ttSS
all tall smooth (TtSs)
7. 1 OoTt:1 Oott:1 ooTt;1 oott
1 oval thick:1 oval thin:1 round thick:1 round thin
8.1RRYy:1RRyy:1RrYy:1Rryy
2 round yellow:2 round green
9. a. the green round plant will produce GR, Gr, gR, and gr gametes in equal proportion since the genes are unlinked
b. this will give 9/16 green round, 3/16 green square, 3/16 red round, and 1/16 red square
10. a) 1 AATt: 1 AAtt: 1 AaTt: 1 Aatt
b) Zero
c) 1/2
11. C. SsYy x SsYy
12. E. SsYY
Offspring could not be homozygous for the dominant yellow seed color (YY), because one recessive y allele must be inhereited from the ssyy parent.
13. All the progeny would be spherical-seeded and intermediate height.
14. BbCc
This is the only possibility for this combination of offspring.
15. 9 agouti: 3 black: 4 albino
This is a variant of the normal 9:3:3:1 ratio for a normal dihybrid cross.
16. A. Parents = wwDD x WWdd
F1 = WwDd white disk
B. Parents = WwDd x WWdd
1/2 white disk and 1/2 white sphere
17. A. Parents = RRBB x rrbb
F1 = RrBb (rough black)
B. This is a dihybrid F2 cross and you should expect 9/16 rough black, 3/16 rough white, 3/16 smooth black, 1/16 smooth white.
18. man = Rrbb inherited an allele for left handedness from his father
father = rr
woman = rrBB (probably no blue alleles in this family but can't be sure)
Parents = Rrbb x rrBB
Children = 1/2 right handed brown eyed; 1/2 left handed brown eyed
19. Man is RrBb
Woman is Rrbb
First child is rrbb. Knowing this you know that each parent must have at least one r and one b.

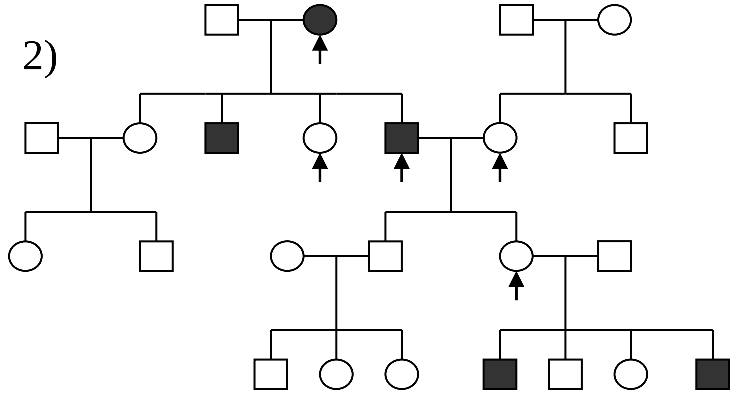
3/8 brown right; 3/8 blue right, 1/8 brown left; 1/8 blue left
20. Man = Rrbb must have allele for left (child 1)
First Wife = RrBb must have allele for left (child 1) and for blue (child 2)
Child 1 = rrBb must have blue allele from father
Child 2 = R?bb
Second Wife = RRBB she is probably homozygous since all nine children are right and brown. Can't be positive.
Nine Children = R?Bb must get blue allele from father
21. BSR 3 BSr 3 BsR 1 Bsr 1 bSR 3 bSr 3 bsR 1 bsr 1

Practice Pedigree Charts Page 1

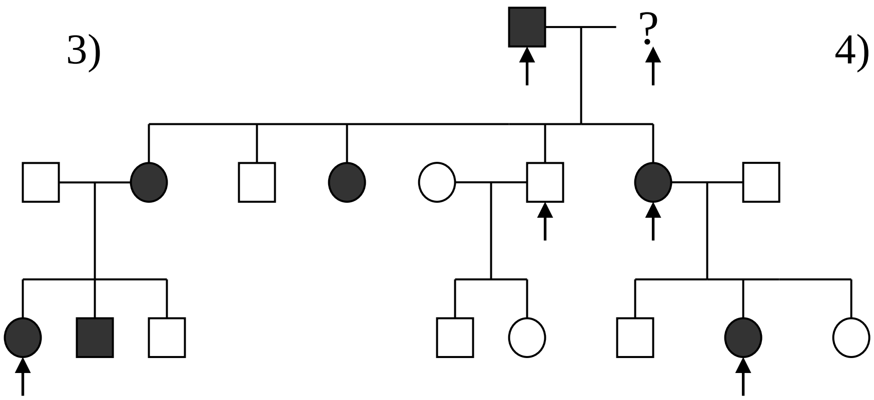
1)



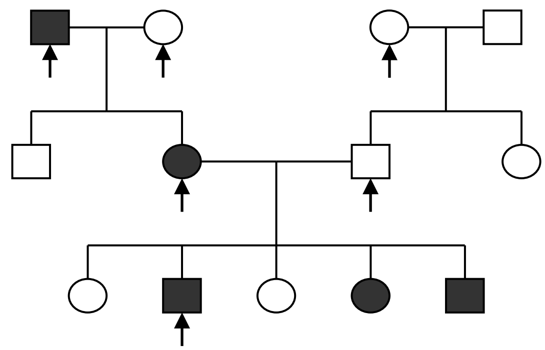
2)



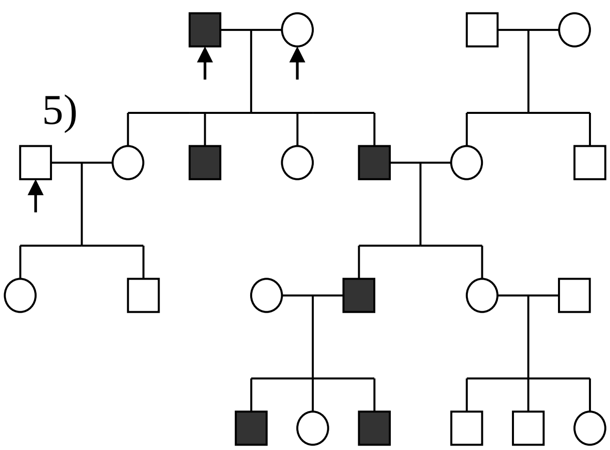
3)



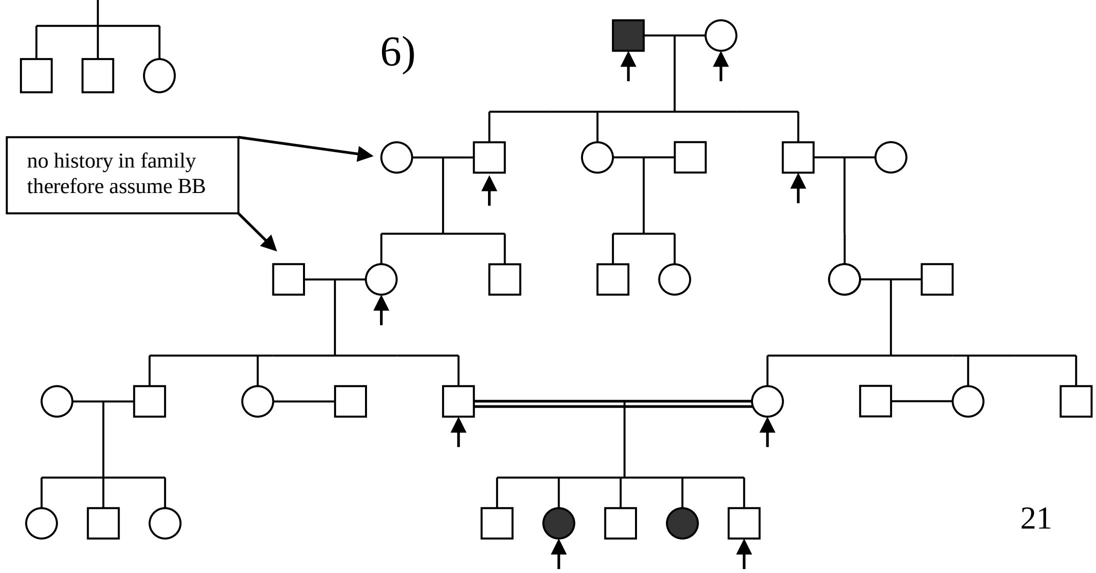
4)



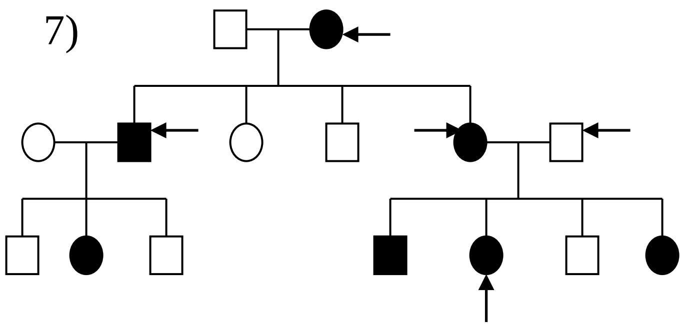
5)



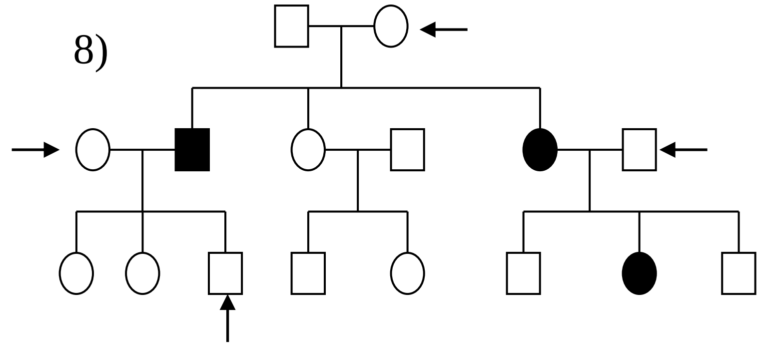
6)



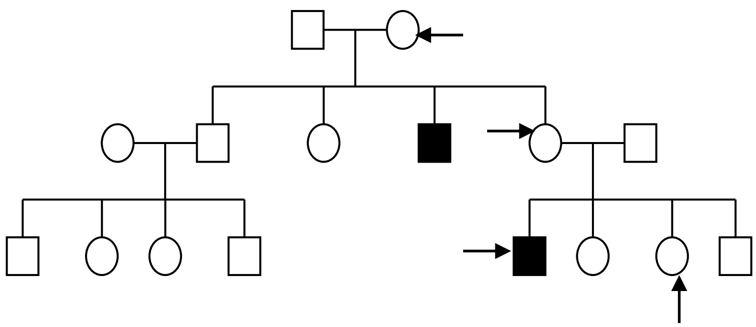
7)



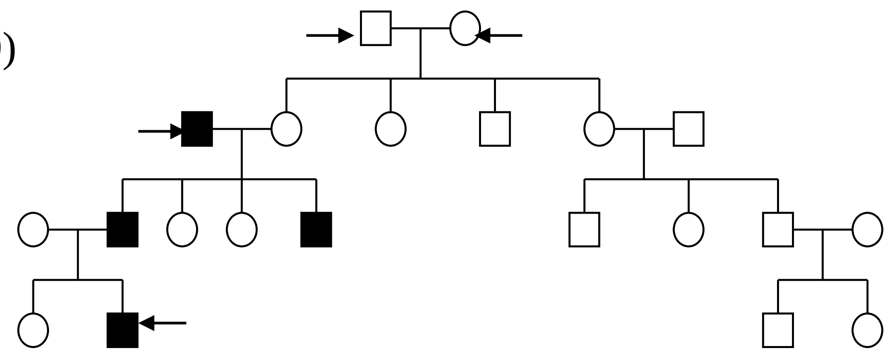
8)



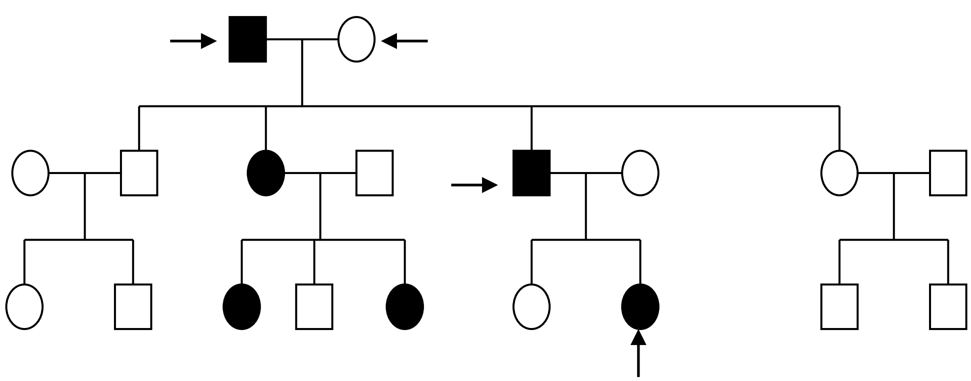
9)



10)



11)



12)