

## Problem 1

A rooster with gray feathers is mated with a hen of the same phenotype. Among their offspring, 15 chicks are gray, 6 are black, and 8 are white.

What is the simplest explanation for the inheritance of these colors in chickens?

**Incomplete or codominance. Feather color is controlled by 2 genes B = black and b = white. The third phenotype is the result of a 50-50 mix of black and white to produce gray.**

**The 15 gray, 6 black, and 8 white birds represent a 2:1:1 ratio—the result of mating two heterozygous individuals: (Bb x Bb)**

	B	b	
B	BB	Bb	<b>1 BB : 2 Bb : 1 bb</b>
b	Bb	bb	

What offspring would you predict from the mating of a gray rooster and a black hen?

A gray rooster (Bb ) mated to a black hen (BB ) can be represented by the following Punnett square:

	B	b
B	BB	Bb
B	BB	Bb

50% of the offspring should be gray (Bb ) and 50% black (BB )

## Problem 2

In some plants, a true-breeding, red-flowered strain gives all pink flowers when crossed with a white-flowered strain: RR (red) x rr (white) ---> Rr (pink).

If flower position (axial or terminal) is inherited as it is in peas what will be the ratios of genotypes and phenotypes of the generation resulting from the following cross: axial-red (true-breeding) x terminal-white?

**Note: Axial (A ) is dominant over terminal (a ).**

**The genotypes of the parents are AARR and aarr. Therefore the gametes of the parents must be AR and ar so the genotype for all the offspring in the**

**F1 generation will be  $AaRr$ , and their phenotype will be axial-pink.**

**What will be the ratios in the F2 generation?**

**The ratio of genotypes can be determined by examining the Punnett square below:**

	AR	Ar	aR	ar
AR	AARR	AARr	AaRR	AaRr
Ar	AARr	AArr	AaRr	Aarr
aR	AaRR	AaRr	aaRR	aaRr
ar	AaRr	Aarr	aaRr	aarr

**The ratio of phenotypes will be:**

<b>6 axial-pink</b>	<b>8 pink</b>
<b>3 axial-red</b>	<b>4 red</b>
<b>3 axial-white</b>	<b>4 white</b>
<b>2 terminal-pink</b>	<b>12 axial</b>
<b>1 terminal-white</b>	<b>4 terminal</b>
<b>1 terminal-red</b>	

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## Problem 3

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Flower position, stem length, and seed shape were three characters that Mendel studied. Each is controlled by an independently assorting gene and has dominant and recessive expression as follows:

Character	Dominant	Recessive
Flower position	Axial (A )	Terminal (a )
Stem length	Tall (T )	Dwarf (t )
Seed shape	Round (R )	Wrinkled (r)

If a plant that is heterozygous for all three characters were allowed to self-fertilize, what proportion of the offspring would be expected to be as follows: (Note - use the rules of probability (and show your work) instead of huge Punnett squares)

a) homozygous for the three dominant traits

$$AATTRR = 1/4 \times 1/4 \times 1/4 = 1/64$$

b) homozygous for the three recessive traits

$$aattrr = 1/4 \times 1/4 \times 1/4 = 1/64$$

c) heterozygous (assumed for each trait)

$$AaTtRr = 1/2 \times 1/2 \times 1/2 = 1/8$$

d) homozygous for axial and tall, heterozygous for seed shape

$$AATTRr = 1/4 \times 1/4 \times 1/2 = 1/32$$


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### Problem 4

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A black guinea pig crossed with an albino guinea pig produced 12 black offspring. When the albino was crossed with a second one, 7 blacks and 5 albinos were obtained.

What is the best explanation for this genetic situation?

**Black is dominant over white**

Write genotypes for the parents, gametes, and offspring.

**First cross:**

Parent's genotypes	= BB (black)	x	bb (white)
gametes	= B		b

**F1 offspring = all Bb**

## Second cross:

Parent's genotypes = Bb (black) × bb (white)

gametes = B or b                      b

F1 offspring = Bb or bb

There should be 50% black to 50% white offspring in this cross.

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## Problem 5

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In sesame plants, the one-pod condition (P ) is dominant to the three-pod condition (p ), and normal leaf (L ) is dominant to wrinkled leaf (l) . Pod type and leaf type are inherited independently. Determine the genotypes for the two parents for all possible matings producing the following offspring:

a. 318 one-pod normal, 98 one-pod wrinkled

Parental genotypes: PPLl × PPLl or PpLl × PPLl

b. 323 three-pod normal, 106 three-pod wrinkled

**Parental genotypes: ppLl × ppLl**

**c. 401 one-pod normal**

**Parental genotypes: PPLL × PpLL or PPLl × PPLL or PPLL × PpLl etc (nine possible genotypes).**

**d. 150 one-pod normal, 147 one-pod wrinkled, 51 three-pod normal, 48 three-pod wrinkled. (a 3: 3: 1: 1 ratio)**

**Parental genotypes: PpLl × Ppll (see below for details)**

	PL	Pl	pL	pl
P1	PPLl	PPll	PpLl	Ppll
p1	PpLl	Ppll	ppLl	ppll

**3 One-pod normal (PPLl , PpLl , PpLl)**

**3 One-pod wrinkled (PPll , Ppll , Ppll)**

**1 Three-pod normal (ppLl)**

**1 Three-pod wrinkled (ppll)**

**e. 223 one-pod normal, 72 one-pod wrinkled, 76 three-pod normal, 27 three-pod wrinkled (a 9: 3: 3: 1 ratio)**

## Parental genotypes: PpLI × PpLI

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### Problem 6

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A man with group A blood marries a woman with group B blood. Their child has group O blood. What are the genotypes of these individuals?

Father = AO (or  $I^A i$ )

Mother = BO (or  $I^B i$ )

First Child = OO (or  $ii$ )

What other genotypes and in what frequencies, would you expect in offspring from this marriage?

Examine the Punnett square to determine the other genotypes possible.

	A	O
B	AB	BO
O	AO	OO

The other genotypes for children are (according



to Campbell's system):  $1/4 I^A I^B$ ,  $1/4 I^A i$ ,  $1/4 I^B i$

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## Problem 7

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Color pattern in a species of duck is determined by one gene with three alleles. Alleles H and I are codominant, and allele i is recessive to both. Note: this situation is similar to the ABO blood system.

How many phenotypes are possible in a flock of ducks that contains all the possible combinations of these three alleles?

As in the ABO blood system 4 phenotypes are possible in this case:

Genotype	Phenotype
HH, Hi	(H)
II, Ii	(I)
HI	(HI)
ii	(i)

## Problem 8

Phenylketonuria (PKU) is an inherited disease caused by a recessive allele. If a woman and her husband are both carriers, what is the probability of each of the following?

Under these circumstances assume the following Punnett square to be true.

	N	n
N	NN	Nn
n	Nn	nn

Where NN or Nn = normal conditions and nn = PKU

a. all three of their children will be of normal phenotype

$$3/4 \times 3/4 \times 3/4 = 27/64$$

b. one or more of the three children will have the disease (x)

$$1 - 27/64 = 37/64$$

All three have x	2 out of 3 has x	1 out of 3 has x	
$\frac{1}{64}$	$+ 3\left(\frac{3}{64}\right)$	$+ 3\left(\frac{9}{64}\right)$	=
	x x o	o o x	
3 Combinations	x o x	o x o	
	o x x	x o o	
$\frac{1}{64}$	$+ 3\left(\frac{3}{4} \times \frac{1}{4} \times \frac{1}{4}\right)$	$+ 3\left(\frac{3}{4} \times \frac{3}{4} \times \frac{1}{4}\right)$	$= \frac{37}{64}$

**Note: the probability of the disease (x) = 1/4 & the probability of being normal (o) = 3/4**

c. all three children will have the disease

$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$$

d. at least one child out of three will be phenotypically normal

(Note: Remember that the probabilities of all possible outcomes always add up to 1)

$$1 - 1/64 = 63/64$$

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## Problem 9

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The genotype of  $F_1$  individuals in a tetrahybrid cross is  $AaBbCcDd$ . Assuming independent assortment of these four genes, what are the probabilities that  $F_2$  offspring would have the following genotypes?

a.  $aabbccdd = \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = 1/256$

b.  $AaBbCcDd = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 1/16$

c.  $AABBCCDD = \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = 1/256$

d.  $AaBBccDd = \frac{1}{2} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{2} = 1/64$

e.  $AaBBCCdd = \frac{1}{2} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = 1/128$

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Just remember that the probability of a heterozygote ( $Xx$ ) =  $2/4$  or  $1/2$  and the probability of a homozygote  $XX$  or  $xx$  =  $1/4$

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## Problem 10

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In 1981, a stray black cat with unusual rounded curled-back ears was adopted by a family in California. Hundreds of descendants of the cat have since been born, and cat fanciers hope to develop the "curl" cat into a show breed. Suppose you owned the first curl cat and wanted to develop a true breeding variety.

How would you determine whether the curl allele is dominant or recessive?

Mate the stray to a non-curl cat. If any offspring have the "curl" trait it is likely to be dominant. If the mutation is recessive, then only non-curl offspring will result.

How would you select for true-breeding cats?

You know that cats are true-breeding when curl crossed with curl matings produce only curl offspring.

How would you know they are true-breeding?

A pure-bred "curl cat" is homozygous.

1. If the trait is recessive any individual with the "curl" condition is homozygous recessive.
  2. If the trait is dominant you can determine if the individual in question is true breeding (CC) or heterozygous (Cc) with a test cross (to a homozygous recessive individual).
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## Problem 11

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What is the probability that each of the following pairs of parents will produce the indicated offspring (assume independent assortment of all gene pairs?)

a.  $AABBCC \times aabbcc \rightarrow AaBbCc$

$$(1)(1)(1) = 1$$

b.  $AABbCc \times AaBbCc \rightarrow AAbbCC$

$$\left(\frac{1}{2}\right)\left(\frac{1}{4}\right)\left(\frac{1}{4}\right) = 1/32$$

c.  $AaBbCc \times AaBbCc \rightarrow AaBbCc$

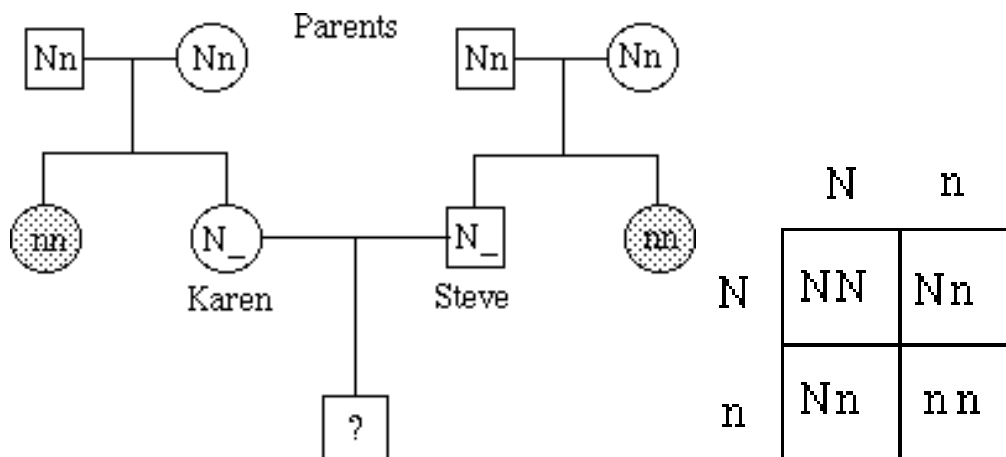
$$\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = 1/8$$

d.  $aaBbCC \times AABbcc \rightarrow AaBbCc$

$$(1)\left(\frac{1}{2}\right)(1) = 1/2$$

## Problem 12

Karen and Steve each have a sibling with sickle-cell disease. Neither Karen, Steve, nor any of their parents has the disease, and none of them has been tested to reveal sickle-cell trait. Based on this incomplete information, calculate the probability that if this couple should have another child, the child will have sickle-cell anemia.



**In order for Karen and Steve to have siblings with sickle**

cell anemia their parents must be carriers (Nn). We also know that John and Carol are not homozygous recessive (nn) because they do not have the disease. Therefore the chance that Karen is a carrier is 2/3 (NN, Nn, nN) and the chance that Steve is a carrier is also 2/3. If they have a child and both Karen and Steve are carriers then the child has one chance in 4 of having sickle cell anemia. Since each event is independent of one another the overall probability of the child having sickle cell anemia is:

$$2/3 \times 2/3 \times 1/4 = 1/9.$$

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### Problem 13

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Imagine that a newly discovered, recessively inherited disease is expressed only in individuals with type O blood, although the disease and blood group are independently inherited. A normal man with type A blood and a normal woman with type B blood have already had one child with the disease. The woman is now pregnant for a second time. What is the probability that the second child will also have the disease? Assume both parents are heterozygous for the "disease" gene.



	<b>Genotype</b>
<b>Father</b>	<b>AO</b>
<b>Mother</b>	<b>BO</b>

	A	O
B	AB	BO
O	AO	OO ←

**OO expresses the disease**

The second child's chance of having the disease is =  $\frac{1}{4} \times \frac{1}{4} = 1/16$

## Problem 14

In tigers, a recessive allele causes an absence of fur pigmentation (a "white tiger") and a cross-eyed condition. If two phenotypically normal tigers that are heterozygous at this locus are mated, what percentage of their offspring will be cross-eyed? What percentage will be white?

Using the Punnett square below where P = normal pigmentation and p = white

	P	p
P	PP	Pp
p	Pp	pp

then 25% will be white (pp) and all of the white offspring will also be cross-eyed

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## Problem 15

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In corn plants, a dominant allele  $I$  inhibits kernel color, while the recessive allele  $i$  permits color when homozygous. At a different locus, the dominant gene  $P$  causes purple kernel color, while the homozygous recessive genotype  $pp$  causes red kernels. If plants heterozygous at both loci are crossed, what will be the phenotypic ratio of the  $F_1$  generation?

	IP	Ip	iP	ip
IP	II PP	II Pp	Ii PP	Ii Pp
Ip	II Pp	II pp	Ii Pp	Ii pp
iP	Ii PP	Ii Pp	ii PP	ii Pp
ip	Ii Pp	Ii pp	ii Pp	ii pp

**Phenotypic ratios:**

**White (I \_ \_ \_) = 12**

**Purple (i i P \_ ) = 3**

**Red ( i i p p) = 1**

**The dominant allele I is epistatic to the p locus,  
and thus the F1 generation will be:**

**9 I\_ P\_ : colorless**

**3 I\_ pp : colorless**

**3 i i P\_ : purple**

**1 i i pp: red**

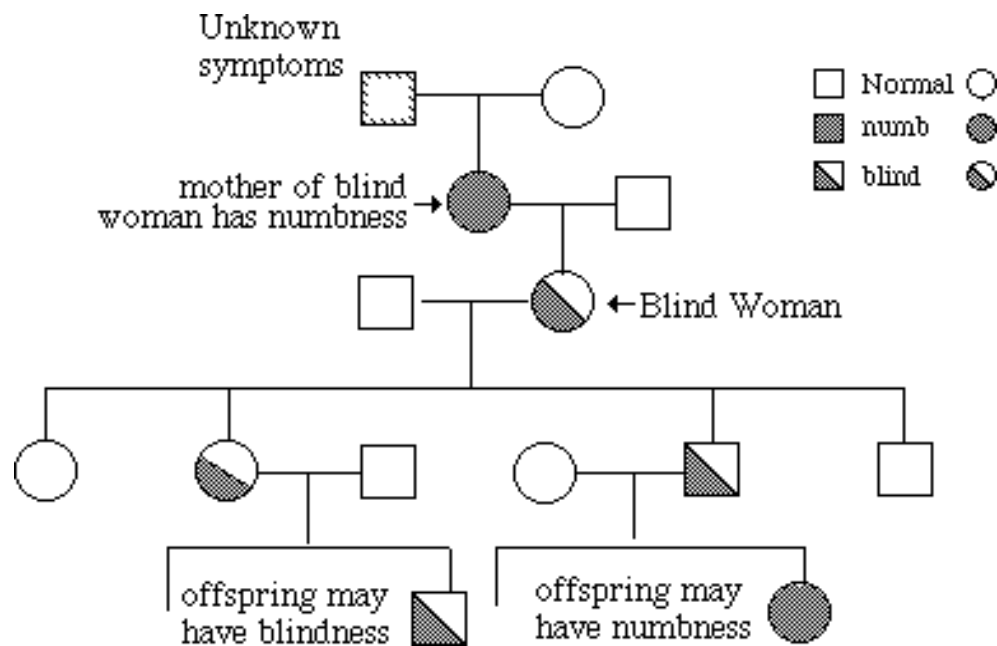
## Problem 16

The pedigree below traces the inheritance of alkaptonuria, a biochemical disorder. Affected individuals, indicated here by the filled-in circles and squares, are unable to break down a substance called alkapton, which colors the urine and stains body tissues. Does alkaptonuria appear to be caused by a dominant or recessive allele?

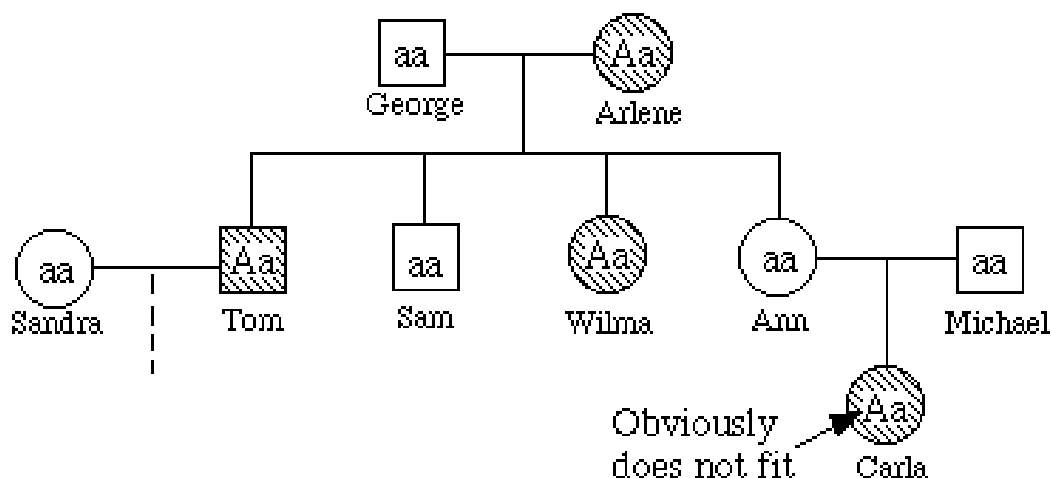
## Recessive

Fill in the genotypes of the individuals whose genotypes you know. What genotypes are possible for each of the other individuals?

If alkaptonuria is recessive George must be a carrier. See below.



If alkaptonuria is dominant Carla could not have the disease, as indicated in the pedigree chart, since the parents do not express the trait. See Below.



## Problem 17

A man has six fingers on each hand and six toes on each foot. His wife and their daughter have the normal number of digits (5). Extra digits is a dominant trait. What fraction of this couple's children would be expected to have extra digits?

Because the daughter is normal the man's genotype must be heterozygous for the trait so:

if X = extra digits and x = normal (5) digits then:

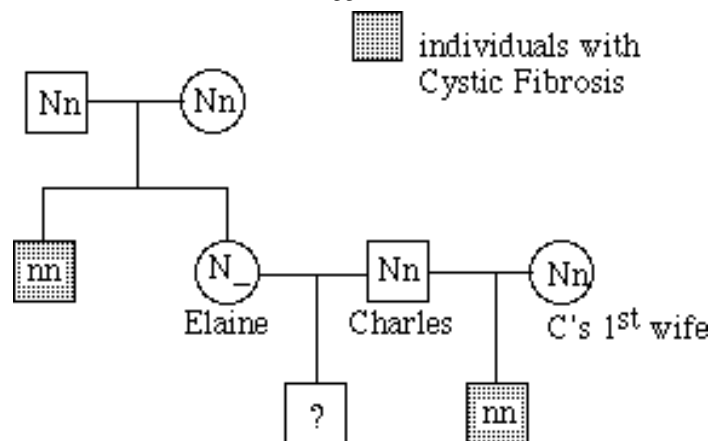


50% of the offspring will be polydactylic

## Problem 18

Imagine you are a genetic counselor, and a couple planning to start a family came to you for information. Charles was married once before, and he and his first wife had a child who has cystic fibrosis. The brother of his current wife Elaine died of cystic fibrosis. Cystic Fibrosis is a lethal recessive condition (a person with CF cannot have children).

What is the probability that Charles and Elaine will have a baby with cystic fibrosis? (Neither Charles nor Elaine has the disease)



The Probability that Elaine is a carrier is  $2/3$   
 (She does not have Cystic Fibrosis which eliminates one of the 4 possibilities. She does have 2 chances out of three of being a carrier. [Nn, nN (carriers) or NN])

The probability that the baby (?) has the disease (if Elaine is a carrier) is  $1/4$

The total probability is  $2/3 \times 1/4$  or  $1/6$ .

## Problem 19

In mice, black color (B ) is dominant to white (b ). At a different locus, a dominant allele (A ) produces a band of yellow just below the tip of each hair in mice with black fur. This gives a frosted appearance known as agouti. Expression of the recessive allele (a ) results in a solid coat color. If mice that are heterozygous at both

loci are crossed, what will be the expected phenotypic ratio of their offspring?

**B = Black - dominant**

**A = Agouti - dominant**

**BbAa x BbAa =**

	Genotype	Phenotype
1	BBAA	agouti
2	BbAA	agouti
2	BBAa	agouti
4	BbAa	agouti
1	BBaa	black
2	Bbaa	black
1	bbAA	white
2	bbAa	white
1	bbaa	white

	BA	Ba	bA	ba
BA	BBAA	BBAa	BbAA	BbAa
Ba	BBAa	BBaa	BbAa	Bbaa
bA	BbAA	BbAa	bbAA	bbAa
ba	BbAa	Bbaa	bbAa	bbaa

**The phenotypic ratio is:**



9 agouti: 4 white: 3 black

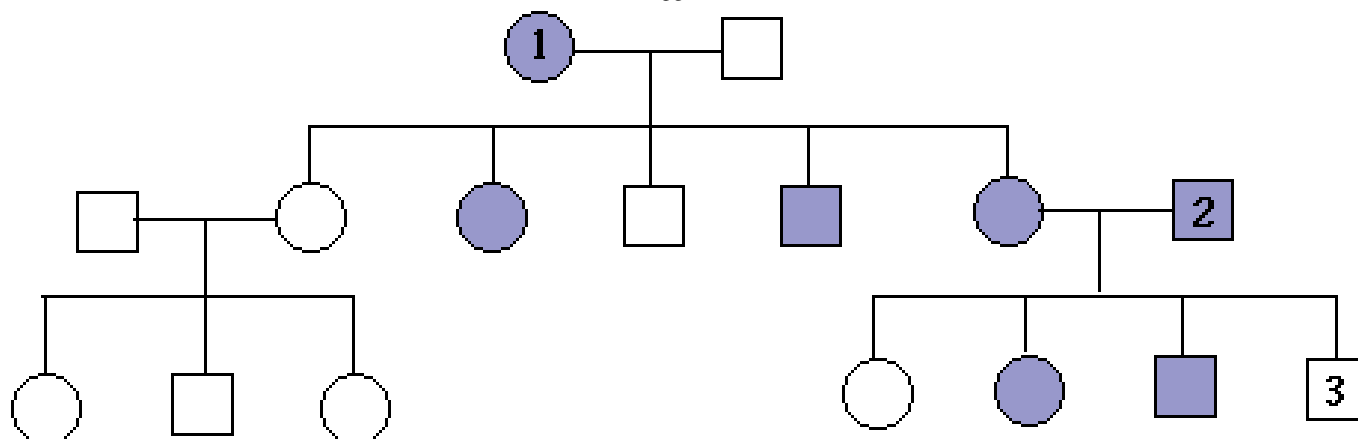
## Problem 20

The pedigree below traces the inheritance of a vary rare biochemical disorder in humans. Affected individuals are indicated by filled-in circles and squares. Is the allele for this disorder dominant or recessive?

The allele is most likely dominant because the #2 individual (see below) with the trait marries a woman with the trait and 50% of their offspring are normal. If the trait were recessive one would expect the following:

$b$ $b$ $b$   $bb$   $hh$	<p>100% of offspring would have the disease, which is not the case.</p>
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What genotypes are possible for the individuals marked 1, 2, and 3?



1. Bb (heterozygous)
2. Bb ( if 2's genotype were bb he would not have the disease and if BB all his children would have the condition.)
3. bb (all normal individuals are homozygous recessive)

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