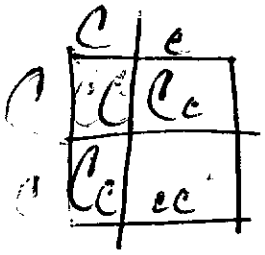
FITCH

Mendellian Genetics Worksheet

Complete the following activities and answer the questions to practice the major concepts at the start of Chapter 14.

1. The gene C causes pigment to form in the hairs of the coat of rabbits. The recessive allele c produces albinism when homozygous. From a cross of Cc X Cc:
   a. How many genotypes would appear in the offspring, and in what ratio?



1 - CC
2 - Cc
1 - cc

   b. What proportion of the pigmented offspring would ~~be homozygous~~?

1/3

   c. If the Cc individuals were also heterozygous for another locus called A (so they would be AaCc), how many types of gametes would such an animal form?

AC, Ac, aC, ac = 4 TYPES OF GAMETES

Cc
Aa
CA
Ca
cA
ca

   d. If the rabbits were heterozygous for n loci, how many genotypes would be possible among the offspring? - Don't worry about this one too much

2^{2n} = TOTAL COMBINATIONS (SOME ARE THE SAME)

3^n = # OF DIFFERENT COMBINATIONS - See attached

2. Two shorthaired dogs are bred to produce a litter of four puppies. ~~Three of the puppies have long hair and one has short hair~~. Assuming that hair length is controlled by a single gene locus, is short hair dominant or recessive? DOMINANT. IF IT WERE RECESSIVE, NONE OF THE OFFSPRING WOULD HAVE LONG HAIR. THE REASON 3 OF 4 PUPS WERE LONG HAIRED IS THAT EACH PUP RESULTS FROM A DIFF SPERM FERTILIZING A DIFF EGG AND RANDOM CHANCE BRINGING TOGETHER THE RECESSIVE ALLELES.
   a. If one of the shorthaired parents were bred to a longhaired dog, what types of offspring would be expected? In what proportions?

Hh X hh = 2 Hh = SHORT HAIR
= 2 hh = LONG HAIR

	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
ABC	AABBCC	AABBCc	AABbCC	AABbCc	AaBBCC	AaBBCc	AaBbCC	AaBbCc
ABc	AABBCc	AABBcc	AABbCc	AABbcc	AaBBCc	AaBBcc	AaBbCc	AaBbcc
AbC	AABbCC	AABbCc	AAbbCC	AAbbCc	AaBbCC	AaBbCc	AabbCC	AabbCc
Abc	AABbCc	AABbcc	AAbbCc	AAbbcc	AaBbCc	AaBbcc	AabbCc	Aabbcc
aBC	AaBBCC	AaBBCc	AaBbCC	AaBbCc	aaBBCC	aaBBCc	aaBbCC	aaBbCc
aBc	AaBBCc	AaBBcc	AaBbCc	AaBbcc	aaBBCc	aaBBcc	aaBbCc	aaBbcc
abC	AaBbCC	AaBbCc	AabbCC	AabbCc	aaBbCC	aaBbCc	aabbCC	aabbCc
abc	AaBbCc	AaBbcc	AabbCc	Aabbcc	aaBbCc	aaBbcc	aabbCc	aabbcc

9

AABBCc - 1
AABBCc - 2
AABBcc - 1
AABbCC - 2
AABbCc - 4
AABbcc - 2
AAbbCC - 1
AAbbCc - 2
AAbbcc - 1

16

9

AaBBCC - 2
AaBBCc - 4
AaBBcc - 2
AaBbCC - 4
AaBbCc - 8
AaBbcc - 4
AabbCC - 2
AabbCc - 4
Aabbcc - 2

32

9

aaBBCC - 1
aaBBCc - 2
aaBBcc - 1
aaBbCC - 2
aaBbCc - 4
aaBbcc - 2
aabbCC - 1
aabbCc - 2
aabbcc - 1

16

$27 = 3^3$

3. Mendel crossed a pea plant from a strain that bred true for purple flowers and short stems with one that had white flowers and short stems. In another cross he used white flowered, long stemmed and white flowered, short stemmed plants as parents. The first cross produced purple flowered, short stemmed offspring, while the second cross produced white flowered, long stemmed offspring.

   a. If the parents were homozygous for these two traits, which characteristics were dominant?

PURPLE DOMINANT

LONG STEMS DOMINANT

X¹ = PP ss X² = pp SS

P, CROSS 1 P, CROSS 2

Pp ss X pp Ss

   b. When the offspring from these two crosses were crossed to one another, Mendel obtained four classes of offspring. What were those four classes? What proportion of the offspring are expected in each class?

PURPLE SHORT WHITE SHORT WHITE, LONG WHITE, SHORT

4. Diagram meiosis in a plant that has two pairs of chromosomes and is heterozygous for the A locus (Aa) located on one chromosome and also for the B locus (Bb) located on the other chromosome. Show stages of both meiotic divisions in sufficient detail to illustrate how all types of gametes are formed in expected proportions.

Aa Bb

INTERPHASE LATE PROPHASE I MI AI TI

CYTOKINESIS TII AII MII PII CYTOKINESIS

Rr rr Rp rp

5. In a certain breed of cattle coat color is determined by a pair of alleles, R and r. RR cattle are red, Rr cattle are roan and rr are white. In this breed both polled (hornless) and horned individuals occur. Polled (P) is completely dominant to horned (p). What are the various kinds of offspring expected from a cross between a heterozygous roan polled bull and a roan horned cow? Give both genotypic and phenotypic ratios.

♂ RrPp × Rrpp ♀

♀	Rp	rp
Rp	RRPp (RED POLLED)	RrPp (ROAN POLLED)
rp	RrPp (ROAN POLLED)	rrPp (WHITE POLLED)

12.5% RRPp RED POLLED
25% RrPp ROAN POLLED
12.5% RRpp RED HORNED
25% Rrpp ROAN HORNED
12.5% rrPp WHITE POLLED
12.5% rrpp WHITE HORNED ♂

6. At some single gene location on a human chromosome, a dominant allele controls tongue rolling, the ability to curl up the sides of the tongue. People who are homozygous for a recessive allele at that locus cannot roll the tongue. At a different gene locus a dominant allele controls whether the earlobes will be attached or pendulous. The attached earlobe is a recessive trait. These two pairs of genes assort independently. Suppose a tongue rolling, detached earlobed woman marries a man who has attached earlobes and cannot roll his tongue. Their first child has the father's phenotypes. Given this outcome, answer the following:

R = roller
r = can't
E = PEND
e = ATTACH

♀ R_Ee
♂ rr ee
F1 rr ee

a. What are the genotypes of the mother, father and child?

♀ = RrEe ♂ = rree F1 = rree

R_Ee × rree ⇒ F1 = rree

b. What is the probability that a second child of theirs will have detached earlobes and won't be a tongue roller?

PROB of rrEe? 25%

(1/2)(1) · (1/2)(1)

= 1/4 = 25%

	re
RE	RrEe
Re	Rree
rE	rrEe
re	rree

7. DNA finger printing is a method of identifying individuals based on locating unique base sequences in their DNA. Before researchers refined the method, attorneys often relied on the ABO flood-typing system to settle disputes over paternity. Suppose you were called upon to testify during a paternity case in which the mother has type A blood, the child has type O blood, and the alleged father has type B blood. How would you respond to the following statements?

♂ = I^B _

♀ = I^A _

F_1 = ii

a. Attorney of the alleged father: "The mother's blood is type A, so the child's type O blood must have come from the father. Because my client has type B blood, he simply could not be the father."

WRONG. IF YOUR CLIENT IS $I^B i$, AND THE MOTHER IS $I^A i$ (WHICH SHE MUST BE, TO HAVE GIVEN ONE OF THE 2 i's TO THE CHILD), YOUR CLIENT COULD HAVE FATHERED THIS CHILD, (WHICH HE COULD BE, TO BE TYPE B.)

b. Mother's attorney: "Because further tests prove this man is heterozygous, he must be the father."

WRONG. EVEN THOUGH THE MAN IS $I^B i$, ANOTHER MAN MAY HAVE GIVEN THE i ALLELE.

THE ONLY THING BLOOD TYPING CAN DO IN PATERNITY SUITS IS DISPROVE THE POSSIBILITY OF A CERTAIN MAN BEING THE FATHER. EXAMPLE.

♀ = ii = O (=MOTHER)

F_1 = A = $I^A i$ (= CHILD)

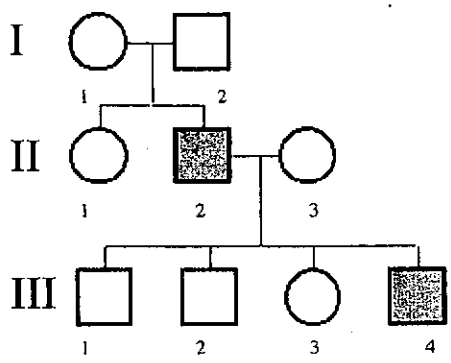
SUSPECTED FATHER = B = I^B _, THIS MAN COULD ONLY HAVE GIVEN AN I^B OR i. MOM HAD TO GIVE AN i. CHILD HAS AN I^A. IT HAD TO COME FROM ANOTHER MAN.

FITCH

Practice Pedigree Problems

Background:

A pedigree is a diagram of family relationships that uses symbols to represent people and lines to represent genetic relationships. These diagrams make it easier to visualize relationships within families. A sample pedigree is below.



Symbols

= Normal male, female

= Male, female who express trait

= Male, female carrier

= Dead male, female

= Sex Unspecified

= Stillbirth

SB SB

= Pregnancy

= Spontaneous abortion

= Terminated pregnancy

Lines

= Generation

= Parents

= Adoption

= Siblings

= Identical Twins

= Fraternal Twins

= Parents closely related

= Former relationship

Questions

1. On the soap opera "The Young and the Restless", several individuals suffer from a rapid aging syndrome in which a young child is sent off to boarding school and returns three months later an angry teenager. Victims have been known to age up to two decades in variations of the disorder. In the Newman family, siblings Nicholas and Victoria aged from ages six and eight to sixteen and eighteen within a few months. Their parents, Victor and Nikki, are not affected; in fact, they never seem to age at all.

a. What is the mode of inheritance of the rapid aging disorder affecting Nicholas and Victoria?

b. How do you know what the mode of inheritance is?

c. Draw a pedigree to depict this portion of the Newman family.

a&b MUST BE RECESSIVE BECAUSE PARENTS DON'T EXPRESS IT.

c. 

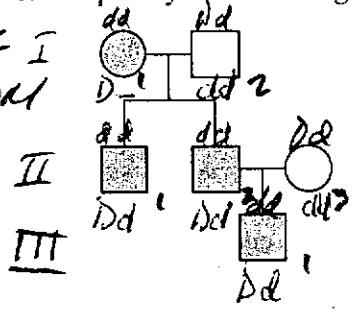
2. Achnodroplasia is a common form of hereditary dwarfism that causes very short limbs, stubby hands, and an enlarged forehead. Below are three pedigrees depicting families with this specific type of dwarfism.

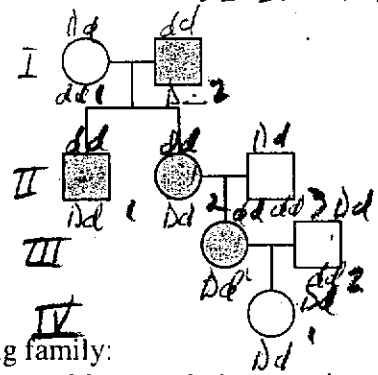
a. Identify the individuals using Roman numerals for the generation and Arabic numerals to identify the individuals.

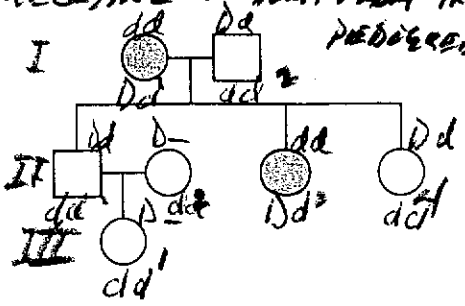
b. What is the most likely mode of inheritance? COMPLETE DOMINANCE, BUT ALLELE COULD BE EITHER RECESSIVE OR DOM. FROM THESE PEDIGREES

c. Explain your reasoning.

PENCIL = REC
PEN = DOM







3. Draw a pedigree to depict the following family:

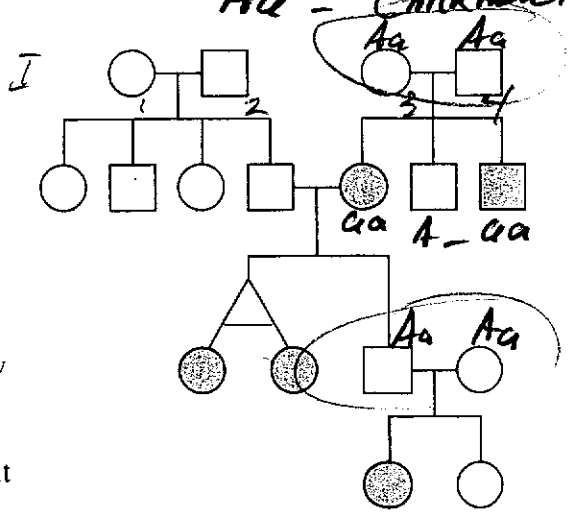
One couple has a son and a daughter with normal pigmentation. Another couple has one son and two daughters with normal pigmentation. The daughter from the first couple has three children with the son of the second couple. Their son and one daughter have albinism; their other daughter has normal pigmentation. - SEE ATTACHED

4. Chands syndrome is an autosomal recessive condition characterized by very curly hair, underdeveloped nails, and abnormally shaped eyelids. In the pedigree below:

a. Identify the individuals using Roman and Arabic numerals.

b. Which individuals must be carriers?

Aa = CARRIERS



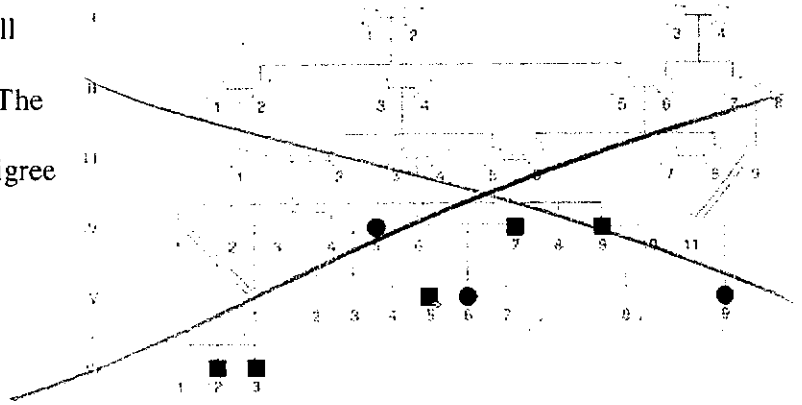
5. Caleb has a double row of eyelashes, which he inherited from his mother as a dominant trait. His maternal gradfather is the only other relative to have the trait. Veronica, a woman with normal eyelashes, falls madly in love with Caleb, and they marry. Their first child, Polly, has normal eyelashes. Now Veronica is pregnant again and hopes they will have a child who has double eyelashes.

a. What chance does a child of Veronica and Caleb have of inheriting double eyelashes?

b. Draw a pedigree of this family. - SEE ATTACHED

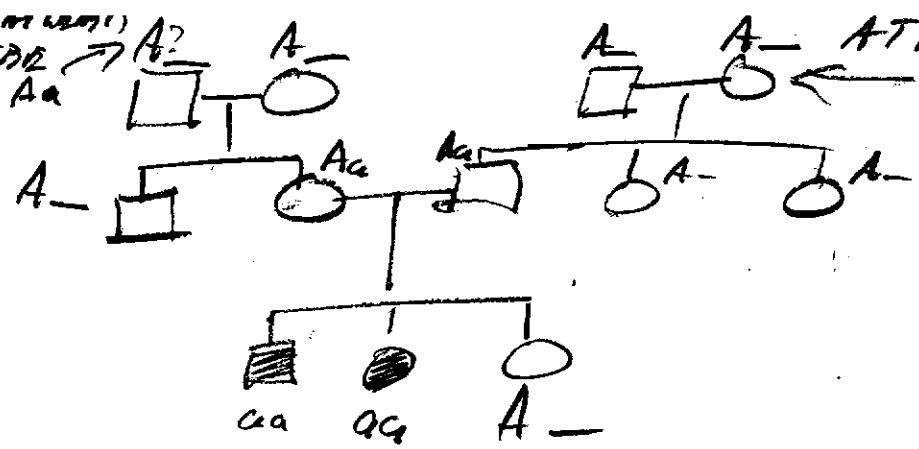
6. Sclerosteosis causes overgrowth of the skull and jaws that produces a characteristic face, gigantism, facial paralysis, and hearing loss. The overgrowth of skull bones can cause severe headaches and even sudden death. In the pedigree below:

a. Which individuals in the pedigree must be carriers?



ONE(OR BOTH) MUST BE → A?

3. Aa



AT LEAST ONE MUST BE Aa

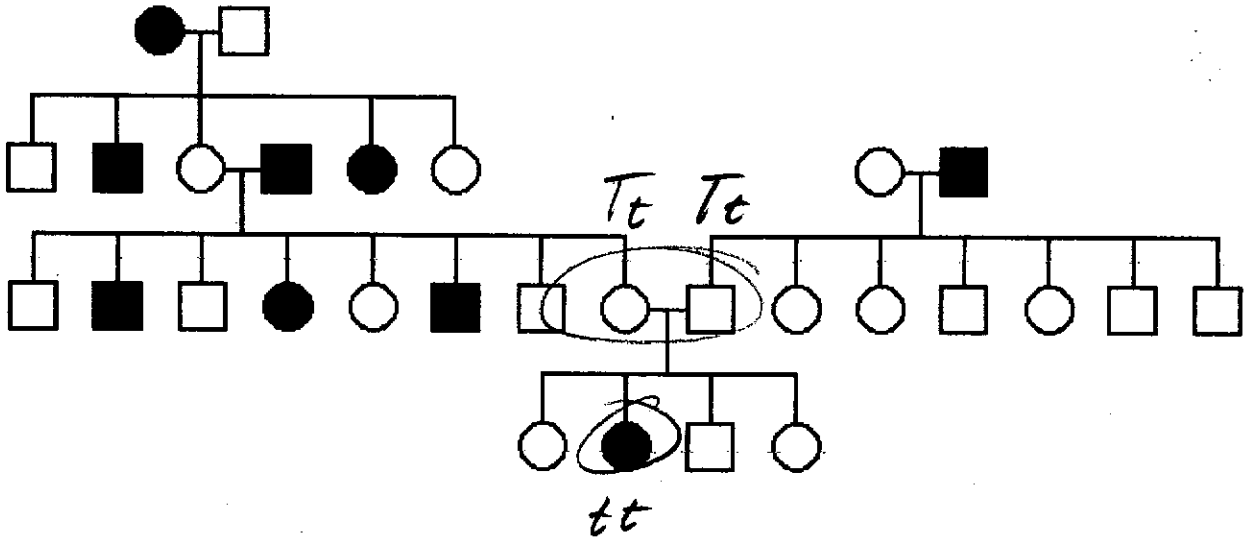
5. CHLOE = D_ ; GRANDFATHER = D_ ∴ CHLOE = Dd

VERONICA = dd ; POLLY = dd

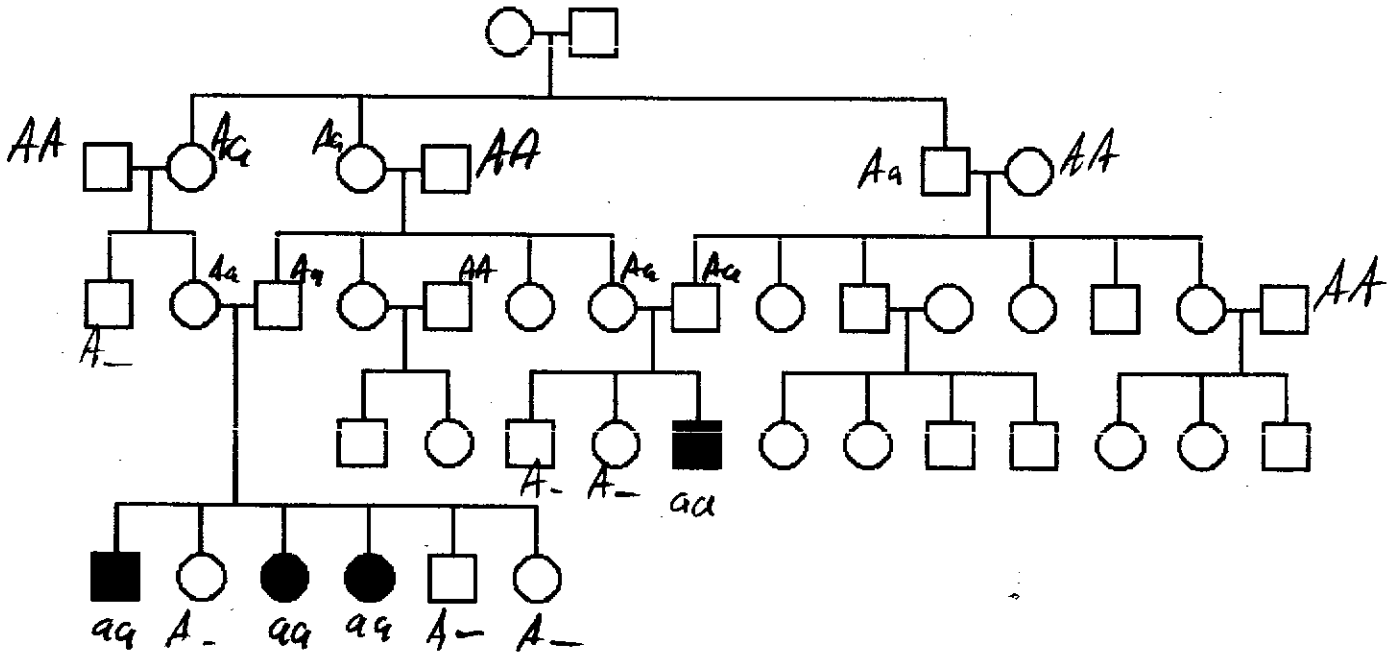
Dd x dd = Dd = 1/2 · 1 = 1/2 CHANCE OFFSPRING HAVE Dd (DOUBLE EYELASHES)

1. Which best describes the genetics of the afflicting allele in the following pedigree (it is a pedigree of taste blindness)?

a. autosomal dominant
b. autosomal recessive

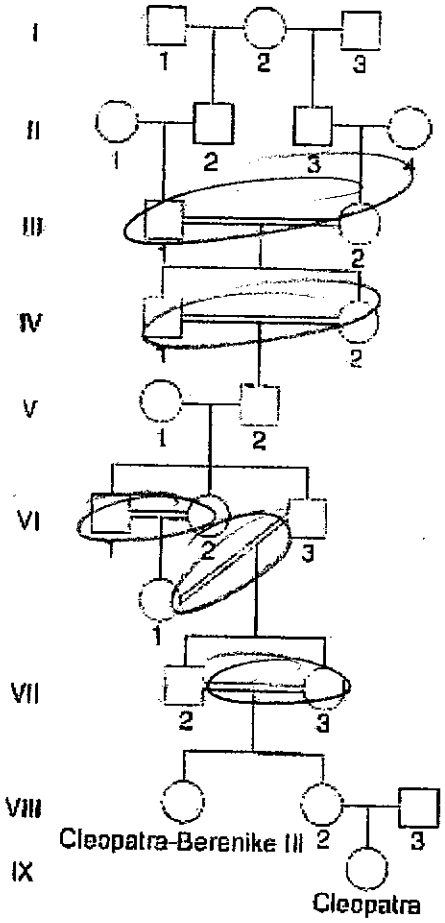


2. Albinism is inherited as an autosomal recessive. In the figure below, assuming that persons from the general population are not heterozygous for albinism (*Aa*), what are the genotypes of all persons whose genotypes are known? (i.e., indicate the genotypes on the figure for all known *AA*, *Aa*, and *aa* individuals)



3. Given the below pedigree, would you expect to find more of in Cleopatra-Berenike III compared with the general population? (figure from p. 283 of R. Lewis, 1998, Life Third Edition. McGraw Hiii, Boston, Mass.

i. Loci which are heterozygous
ii. Loci which are homozygous for rare alleles
iii. Loci which display epistasis
iv. Loci which display codominance
v. Alleles
vi. Loci



4. 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?

aa X aa = 100% aa - ALL AFFECTED - NO CARRIERS

Sound familiar? And no Punnett square needed (whew). Therefore, you can **avoid** doing a Punnett square if you can reduce the problem to a series of probability statements.

With a **tri-hybrid** cross, you can avoid a huge Punnett square with 64 boxes:

The chance of **yellow** (YY or Yy) seeds	= 3/4 (the dominant trait)
The chance of **round** (RR or Rr) seeds	= 3/4 (the dominant trait)
The chance of **purple** (PP or Pp) flowers	= 3/4 (the dominant trait)
The chance of **green** (yy) seeds	= 1/4 (the recessive trait)
The chance of **wrinkled** (rr)seeds	= 1/4 (the recessive trait)
The chance of **white** (pp) flowers	= 1/4 (the recessive trait)

FILL IN THE BLANKS AND EXPECTED PROPORTIONS:

1. Pea plant with purple flowers and round, yellow seeds:	= 3/4 x 3/4 x 3/4 = 27/64
2. Pea plant with purple flowers and wrinkled, yellow seeds:	= 3/4 x 3/4 x 1/4 = 9/64
3. Pea plant with purple flowers and round, green seeds:	= 3/4 · 3/4 · 1/4
4. Pea plant with purple flowers and wrinkled, green seeds:	= 3/4 · 1/4 · 1/4
5. Pea plant with white flowers and round, yellow seeds:	= 1/4 · 3/4 · 3/4
6. Pea plant with white flowers and wrinkled, yellow seeds	= 1/4 · 1/4 · 3/4
7. Pea plant with white flowers and round, green seeds	= 1/4 · 3/4 · 1/4
8. Pea plant with white flowers and wrinkled, green seeds:	= 1/4 · 1/4 · 1/4

Try this problem:

You have freckles, dimples, and a widow's peak. Your **S.O.** has freckles and dimples, but a continuous hairline. In other words,

TRIHYBRID CROSS

You		**Your S.O.**
FfDdWw	x	FfDdWw

1/2 · 1/2

Question: What is the chance your darling child would have all three recessive phenotypes: no freckles (ff), no dimples (dd) or a continuous hairline (ww)?

1/2 · 1/2 1/2 · 1/2 1/4 · 1/4 · 1/4 = 1/64

Hint: do three quick Punnett squares for each single trait. Take the proportions of the recessives and multiply away...!

But what if:

You		**Your S.O.**
FfDdWw	x	Ffddww

1/2 · 1/2

Question: What is the chance your darling child would have all three recessive phenotypes: no freckles (ff), no dimples (dd) or a continuous hairline (ww)?

1/2 · 1 1/2 · 1 1/4 · 1/2 · 1/2 = 1/16

1. $\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{16}$

1. What is the probability that if a couple has 4 children that all 4 will be of the same sex?
2. What is the probability that if a couple has 4 children that they will have 2 boys and 2 girls, in any order?
3. A woman has a father who died of Huntington's disease. What is the probability that she will develop the symptoms of the disease?
4. A couple are both tested and found to be carriers of the cystic fibrosis gene. If they have 2 children, what is the chance that both will be affected by cystic fibrosis? What is the chance that both will be carriers?
5. For the couple in #4, what is the chance that they will have 2 girls that are both affected by cystic fibrosis?
6. CHALLENGE QUESTION: A family has two children. You are told that one of the two children is a boy. What is the probability that they have a boy and a girl (in any order)?

1. $\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{16}$

2. $\frac{1}{2}$ BUT NOT SURE WHY.

3. HUNTINGTONS = DOM. ALLELE
   IF ♂ = Hh = PROB. OF GETTING H = $\frac{1}{2}$
   IF ♂ = HH = " " = 1

4. Ff x Ff = $\frac{1}{4}$ = ff x 2 KIDS = $\frac{1}{4} \cdot \frac{1}{4} = \frac{1}{16}$
   ∴ $\frac{1}{16}$ CHANCE OF BOTH HAVING CF

   Ff x FF = $\frac{1}{2}$ = Ff => $\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ CHANCE
   BOTH ARE CARRIERS
   Girl Girl Aff Aff

5. $\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{4} \cdot \frac{1}{4} = \frac{1}{64}$ BOTH ARE ♀ AND HAVE CF

6. $\frac{1}{2}$ - COULD BE 1 BOY + 1 BOY OR ($\frac{1}{2}$)
   COULD BE 1 BOY + 1 GIRL ($\frac{1}{2}$)
   = $\frac{1}{2}$