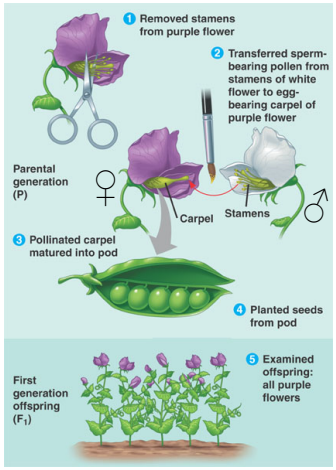
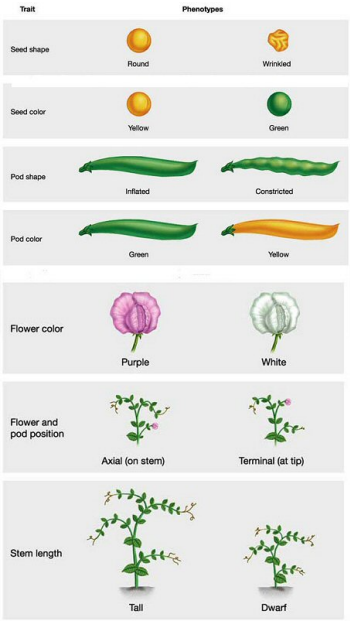


Gregor Mendel (1822 - 1884)

- offspring were all purple like the female parent
- What would you do next?



Mendel noticed:

- one trait always masked the other
- we call this the dominant trait
- it didn't matter whether the trait came from the mother or father
- IMPORTANT! Dominant does not mean most common in the population. The recessive allele might be more common.

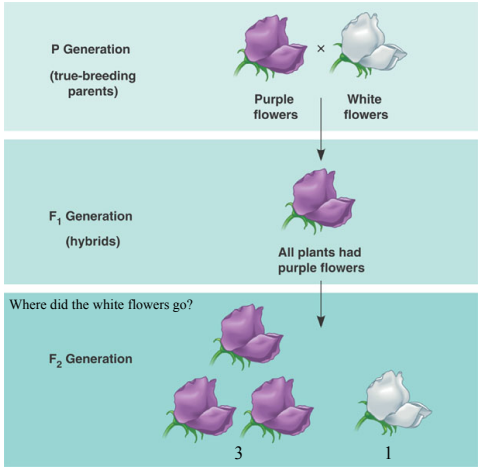
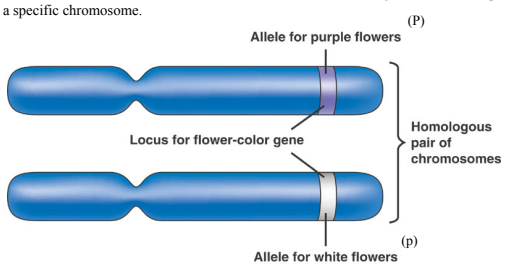


Table 14.1 The Results of Mendel's F_1 Crosses for Seven Characters in Pea Plants

Character	Dominant Trait	×	Recessive Trait	F_2 Generation Dominant:Recessive	Ratio
Flower color	Purple	×	White	705:224	3.15:1
Flower position	Axial	×	Terminal	651:207	3.14:1
Seed color	Yellow	×	Green	6022:2001	3.01:1
Seed shape	Round	×	Wrinkled	5474:1850	2.96:1
Pod shape	Inflated	×	Constricted	882:299	2.95:1
Pod color	Green	×	Yellow	428:152	2.82:1
Stem length	Tall	×	Dwarf	787:277	2.84:1

Mendel developed a hypothesis consisting of three ideas:

1. Genes occur in different versions, called alleles. Remember each gene resides at a specific locus on a specific chromosome.



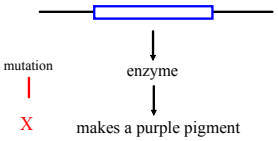
2. For each trait, an organism inherits two alleles, one from each parent.

3. The dominant allele masks the presence of the other, recessive allele, and determines the appearance of the organism.

He developed two laws that govern inheritance:
1. Law of **Segregation**
The two alleles for a trait separate during gamete production and end up in different gametes.

2. Law of I**ndependent Assortment** says that the alleles segregate independent of one another.

How does an allele affect a phenotype?



Which allele is this?

Which allele is it with the mutation?

We can say three things about genes and chromosomes:
1. Genes occupy specific loci on chromosomes

2. Homologous chromosomes separate during meiosis

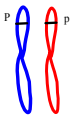
- segregation of alleles to different gametes

3. Non-homologous chromosomes are separated by independent assortment

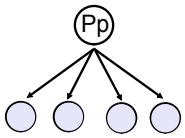
- inheritance of one allele does not affect the inheritance of another

If we think about what chromosomes do during meiosis, we can better understand how alleles are inherited.

Chromosome pair 1

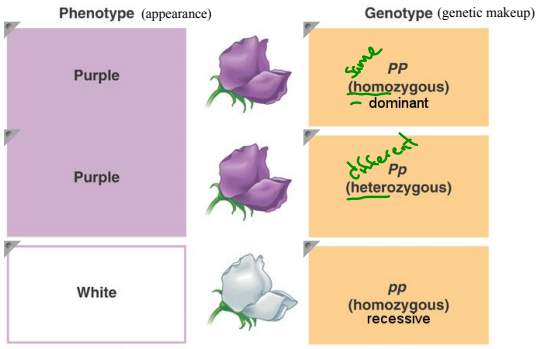


What alleles can be present in gametes from this parent?



What if we consider another pair of chromosomes?

Notice that each gamete gets one of each letter (*i.e.*, one allele for each trait)



1. Serendipity played a big part in Mendel's choice of the garden pea. Explain.

2. Explain how the dominant phenotype can have more than one genotype.

3. A mother has two alleles for a given trait. How many does she give to an offspring? What principle of genetics describes this?

4. Plants grown by vegetative propagation (*i.e.*, by cuttings) have exactly the same traits as the parent plants. Plants grown from seeds may vary from the parent plants in many ways. Explain.

5. What principle of genetics states that the inheritance of one characteristic does not affect the inheritance of another?

6. Does the height of a pea plant affect the color of its flowers? Why or why not?

7. Is it possible to be heterozygous for a trait and show the recessive phenotype? Explain.

8. Of all the chromosomes in one of your cells, half came from each of your parents. About what fraction came from each of your grandparents? Your great-grandparents?

A purple flowered plant and a white flowered plant are crossed. Both parents are true breeding. Find the genotype and phenotype of the F_1 and F_2 offspring.

homozygous

Step 1 - What are the genotypes of the parents?

PP x pp

Step 2 - What are all possible combinations of alleles in gametes?
- separate the letters

P, P p, p

- remember these are gametes from EACH parent

Step 3 - What are all possible combinations of gametes?
- put the letters together

Pp, Pp, Pp, Pp

all purple

Without a Punnett square

Now for the F_2

Step 1 - What are the genotypes of the parents?
- the parents are taken from F_1

Pp x Pp

Step 2 - What are all possible combinations of alleles in gametes?

P, p P, p

PP, Pp, Pp, pp

Step 3 - What are all possible combinations of gametes?
- write the gametes from one parent at the top
- write the gametes from the other parent along the side
- fill in the square to show the combinations

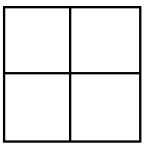
	P	p
P	PP purple	Pp purple
p	Pp purple	pp white

- an individual that is heterozygous for one trait is called a **monohybrid**
- a cross between two heterozygotes is called a **monohybrid cross**

e.g., Use a Punnett square to determine the offspring of a cross between a heterozygous purple plant and a white plant.

With Punnett square

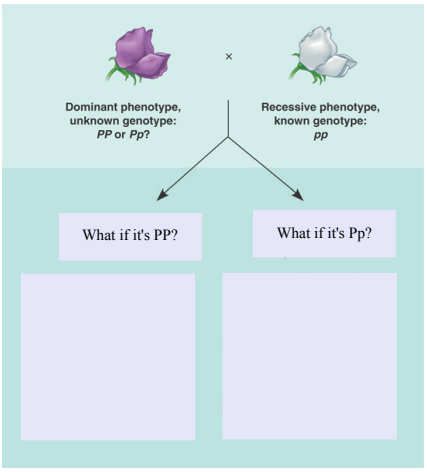
Without Punnett square



phenotype?

Important points:
- remember, these are POSSIBILITIES for offspring
- we are saying that, from this cross, there are two possible types of offspring
- we cannot say anything about how many offspring of which phenotype are *actually* produced

How do we choose symbols for traits?



Imagine you have an organism with a dominant phenotype.

Is it homozygous or heterozygous?

- use a test cross to find out
- cross the unknown with a homozygous recessive

A Punnett square can also be used to figure out the genotypes of the parents from the offspring.

	b	b
B or b?	Bb	Bb
B or b?	Bb	Bb

	f	f
F or f?	Ff	Ff
F or f?	ff	ff

9. In a monohybrid cross between homozygous dominant and homozygous recessive parents, there are 32 offspring in the F_2 generation. How many of the offspring would you expect to show the recessive trait?

10. What is a test cross? Why does one use it? Explain the two possible outcomes and what it tells you.

11. In sheep, white coat is dominant. Black is recessive. Occasionally, a black sheep appears in a flock. Black wool is worthless. How could a farmer eliminate the genes for black coat from the flock?

12. In a certain animal, one variety always has a hairy tail while another always has a naked tail. How would you determine which trait is dominant?

Do traits always travel together or are they inherited separately?

If they traveled together we would expect:

YRyr

YRyr	YR	yr
YR	YYRR	YyRr
yr	YyRr	yyrr

Expected results?

. . . but this is usually not what we see.

To figure out what might happen, we would have to consider two traits at once.

Do the dihybrid cross coin toss activity.

# of individuals

	yellow, round	yellow, wrinkled	green, round	green, wrinkled
totals				

P YYRR x yyrr

gametes

F_1 phenotype?

- remember that gametes get one of each letter
- *i.e.*, an allele from each gene
- in this case, a "Y" and an "R"

What about F_2

YyRr

YyRr				

yellow, round

yellow, wrinkled

green, round

green, wrinkled

A pea plant heterozygous for purple flowers and producing wrinkled seeds is crossed with a plant homozygous for purple flowers and heterozygous for round seeds.

P Pprr x PPRr

Gametes

F_1

Common errors

1. Mixing letters before making gametes.

Pprr x PPRr

2. Not giving gametes one of each letter.

So, how do we predict the chance of getting a certain combination?

$$P = \frac{\text{\# correct outcomes}}{\text{total \# outcomes}}$$

What you want

All the possibilities

0 — 1

no chance of occurring

occurs every time

Independent events - previous events do not affect future events

Rule of multiplication - probability that one event AND another event occur

P(1 and 2) = P(1) x P(2)

e.g., Toss a coin twice. What is the probability of getting heads both times?

P (H,H) = P (H) x P(H)

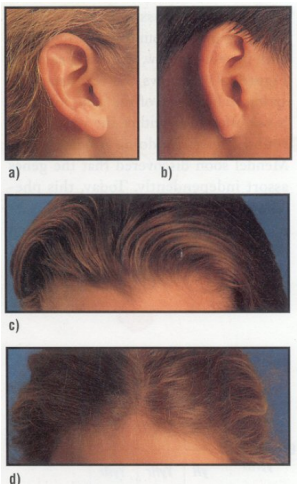
Rule of addition - probability that one event OR another event occur

P(1 or 2) = P(1) + P(2)

e.g., A woman has a baby. What is the probability that it is either a boy or a girl?

P (boy or girl) = P(boy) + P(girl)

e.g., Two parents are heterozygous for widow's peak and free earlobes. What is the probability of having a child with widow's peak and attached earlobes?



Parents are

P (widow, attached) = P (widow) x P (attached)

Think of this as 2 monohybrid crosses.

P Ww x Ww

F_1 WW, Ww, Ww, ww

Probability of widow's peak?

P Ff x Ff

F_1 FF, Ff, Ff, ff

Probability of attached earlobes?

P(widow's peak and attached earlobes)

= P(widow's peak) x P(attached earlobes)

$= \frac{3}{4} \times \frac{1}{4}$

$= \frac{3}{16}$

Imagine a pea plant produces purple flowers and seeds that are yellow and round. It is heterozygous for all three traits. It is crossed with a pea plant that is heterozygous for purple flowers and produces seeds that are green and wrinkled.

Find the probability that the offspring will produce white flowers and seeds that are green and round or will produce purple flowers and seeds that are green and wrinkled.

Parents PpYyRr x Ppyyrr

P (white, green, round) = P (white) x P (green) x P (round)

Answer:

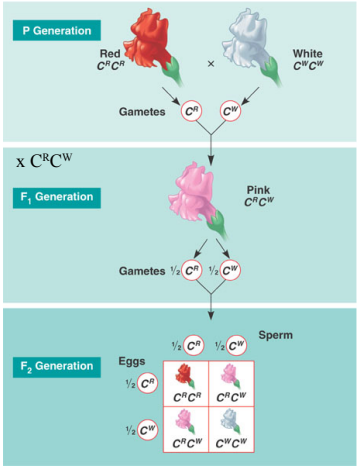
13. A couple has three sons and one daughter. What is the probability that a fifth child will be female? Explain your answer.

14. Explain why probability is a useful genetic tool.

15. Explain why a large sample is more statistically reliable than a small sample?

incomplete dominance

codominance



P

g

F_2

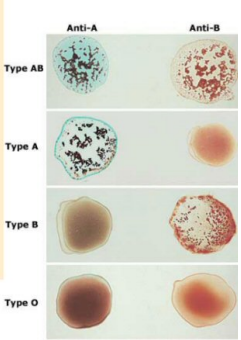
phenotype?

multiple allele inheritance

- traits that are controlled by genes for which more than two alleles exist
- remember that, although more than two exist, each individual has only two

Genotype	Phenotype (Blood Group)	Red Blood Cells
I^AI^A or I^Ai	A	A protein
I^BI^B or I^Bi	B	B protein
I^AI^B	AB	
ii	O	

The alleles are:
I^A, I^B, i



e.g., The mother is heterozygous for type A and the father is heterozygous for type B.

P I^Ai x I^Bi

gametes I^A, i I^B, i

F_1 I^AI^B, I^Ai, I^Bi, ii

16. A roan calf's parents were a white cow and a red bull. What is the roan's genotype? Can two roans mate and produce all roans? Explain.

17. A flower grower is looking for new varieties of petunias. He crosses a yellow flower plant with a blue one and gets green flowered plants. Explain how this is possible.

18. What makes the inheritance of human ABO blood groups interesting?

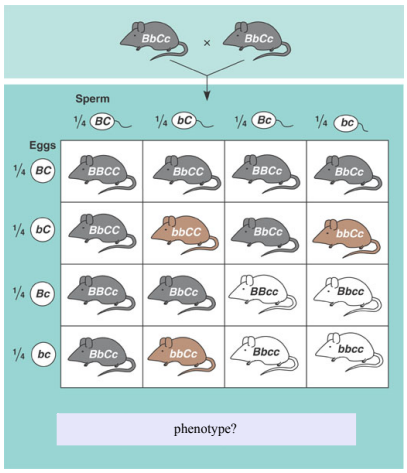
19. Mary has blood type A and she marries John , whose blood type is B. They have three children: Joan. James and Pete. Joan has blood type O, James has blood type A, and Pete has blood type B. Explain how this is possible.

20. If a man who has type O blood marries a woman who is heterozygous for type B blood, what is the probability of them having a child with B type blood? Type O blood?

21. Mr. and Mrs. Doe had a child named Flo at the same time Mr. and Mrs. Roe had their son Joe. The Roes took Joe home, and after looking at him they claimed that Joe was not their child. They were going to sue the Hospital for the mix up. The Hospital took the blood types of all six individuals to try and prove there was no mix up. The results of the tests were as follows: Mr. Roe had A blood type; Mrs. Roe had A blood type; Joe had O blood type; Mr. Doe had O blood type; Mrs. Doe had AB blood type and Flo had A blood type. Was there a mix up? Explain.

epistasis

- one gene affects the phenotypic expression of a separate gene



In some dogs, the B allele causes black coat and the b allele causes brown coat. A separate gene controls the production of pigment. The W allele prevents pigment formation and the w allele allows it.

wwBB -

wwBb -

wwbb -

WwBb -

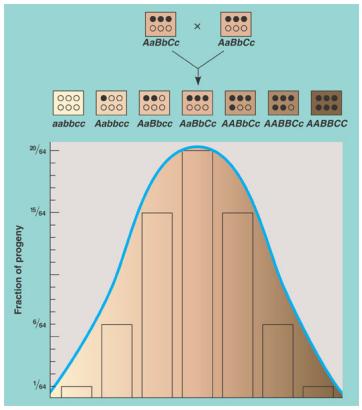
Wwbb -

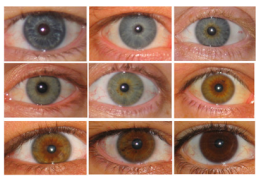
e.g., BbWw x Bbww

Find the probability that a pup will be (a) brown, and (b) white

a)
=
=
=

b)
=





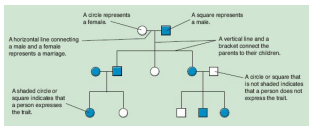
- there are likely at least 16 genes responsible for human eye color

- your actual color is determined by the amount of pigment on the back of the iris, which varies from brown to black

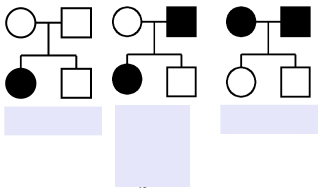
- the amount of pigment in the fluid in front of the iris determines how much light is scattered to produce green and blue eyes

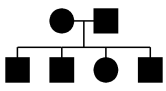
How does an allele cause a disorder?
- an allele may result in a protein that does not function
- if the allele is recessive, heterozygous individuals might be normal

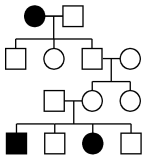
A pedigree can:
- help us determine whether someone is a carrier (*i.e.*, heterozygous) or not
- determine the probability that a child will be affected

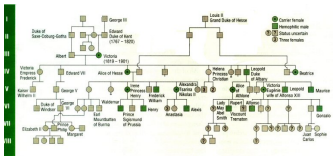


What inheritance pattern explains each of these?

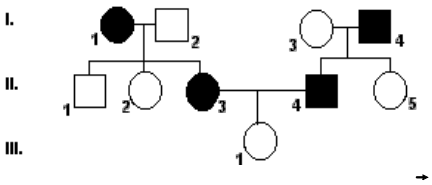








Examine the pedigree in Figure 1, which traces the dimples trait through three generations of a family. Blackened symbols represent people with dimples. Circles represent females, and squares represent males.



1. Read the following text, describing the family shown in Figure 1. Write the name of each person below the correct symbol in the pedigree.

Although Jane and Joe Smith have dimples, their daughter, Clarissa, does not. Joe's father has dimples, but his mother, and his sister, Grace, do not. Jane's father, Mr. Renaldo, her brother, Jorge, and her sister, Emily, do not have dimples, but her mother does.

2. Take another look at Figure 1. A genetic counselor analyzing this pedigree suggests that a person only needs to have one dominant allele for dimples (D) in order to have dimples. If this is true, what is the genotype of Person 1 in the third generation of Figure 1?

3. What is the genotype of Person 4 in the second generation of Figure 1?

4. What is the genotype of Person 4 in the first generation of Figure 1?

5. Construct a pedigree based on the following passage about curly hair. Write the names of each person on the pedigree next to their correct symbol.

Andy, Penny, and Delbert have curly hair, but their mother, Mrs. Cummins, does not. Mrs. Giordano, Mrs. Cummin's sister, has curly hair, but her parents, Mr. & Mrs. Lutz, do not. Deidra and Darlene Giordano have curly hair, but their sister, Katie, like her father, has straight hair.

A researcher named Morgan was working on the genetics of fruit flies. After a year of breeding them and looking for mutants, he discovered a single male with white eyes rather than the normal red.

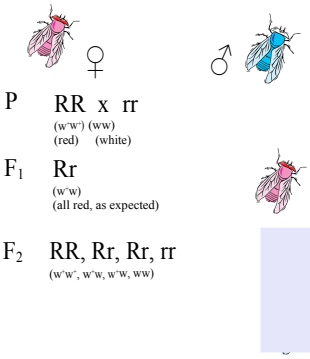
Normal phenotype (wild type): *e.g.*, red eyes (w^+)

Mutant phenotypes (originate as mutations): *e.g.*, white eyes (w)

Notice the new symbols
Recessive mutation: lower case letter
Dominant mutant allele: upper case letter
Wild type is given a + superscript

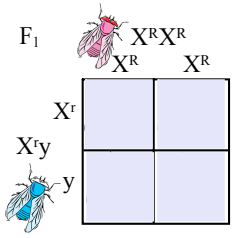
e.g.,
Curly wings
(dominant allele mutation) Cy

Normal wings Cy^+

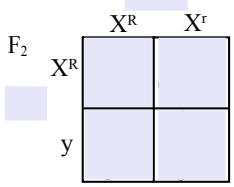


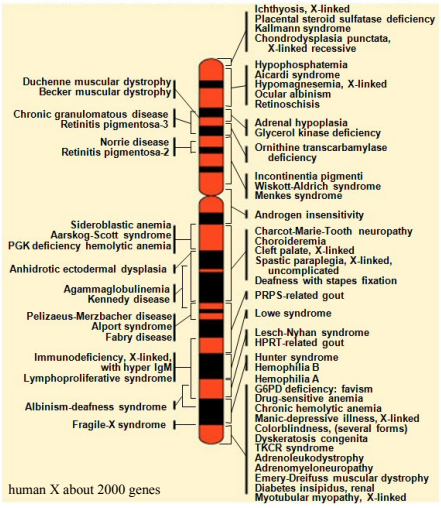
What was going on here?

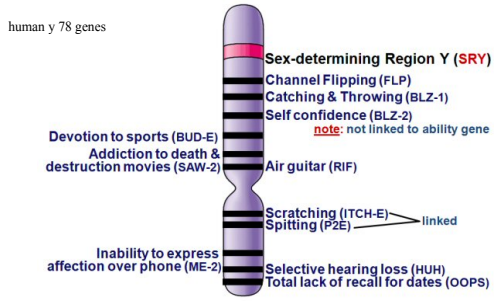
- the sex of the fly seemed to be affecting eye color
- what if the gene is on the X chromosome?



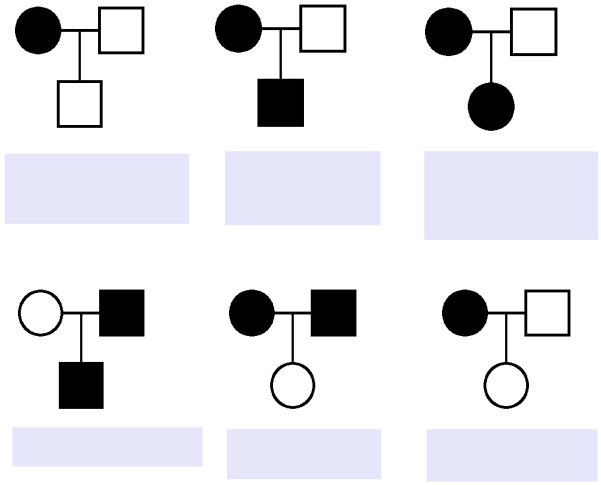
Remember,
X^A = normal (dominant)
X^a = the trait (recessive)
y = y chromosome (males only)

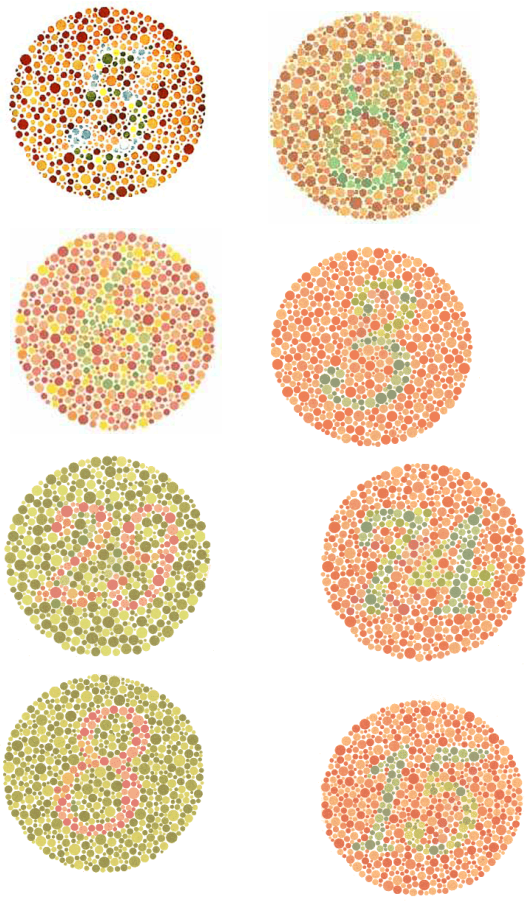






Is it possible that this pedigree is for an X-linked recessive trait?

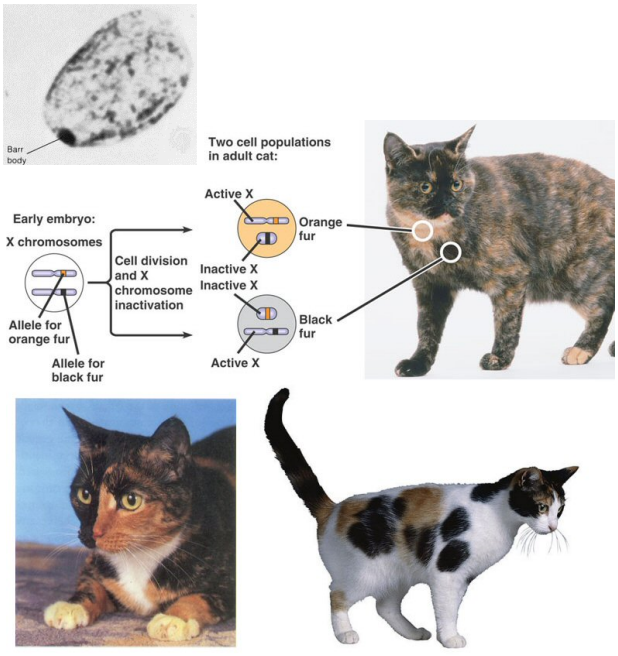




22. Huntington's chorea is a dominant neurological disorder that usually appears when a person is between 35 and 45 years of age. Many people with Huntington's chorea, however, do not show symptoms until they are well into their sixties. How does the slow development of the disease explain why it has not been eliminated by natural selection.

23. Explain the significance of identifying the alleles which cause genetic disorders.

24. In most cultures, it is unacceptable to marry your immediate relatives. Using the principles of genetics, explain why inbreeding in humans is discouraged.



P b^+bvg^+vg x bbvgvg

gametes b^+vg^+, b^+vg, bvg^+, bvg bvg

F1

expected

actual

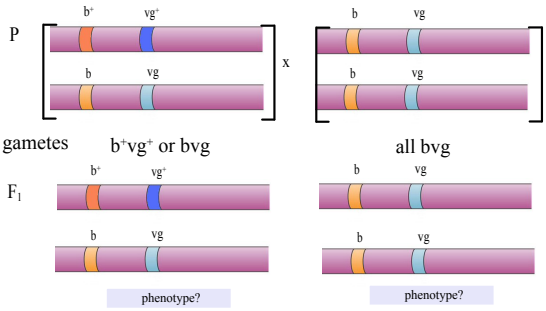
b^+ = gray body
b = black body

vg^+ = normal wing
vg = vestigial wing

- remember independent assortment means that all combinations are equally probable
- So why were the offspring not present in equal numbers?

What if the genes were on the same chromosome?
- there must be many genes on each chromosome because there are far more genes than chromosomes

- linked genes are genes that tend to be inherited together because they are on the same chromosome

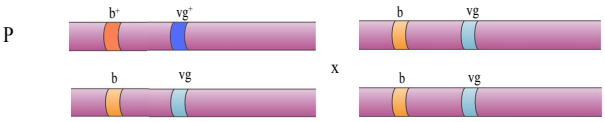


heterozygous parent

homozygous parent

1:1
- *i.e.*, we expect an equal number of each of the parental types and none of anything else

So, where did the ones who don't look like the parents come from?



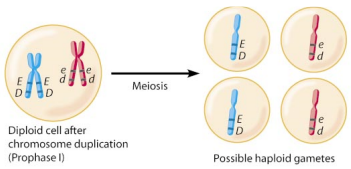
heterozygous females

F_1

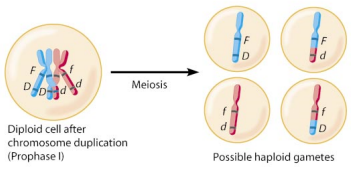
homozygous males	b+ vg	b vg+
b vg	b+b vgvg	bb vg+vg
b vg	b+b vgvg	bb vg+vg

1:1
- *i.e.*, we expect an equal number of each

Question



(b) Linked genes end up together in the absence of crossing over



(c) Linked genes do not end up together when crossing over occurs

# of times a is on the same chromosome as										
b										
c										
d										
e										
f										
g										
total rolls										

- crossing over is random so it should occur more often between two genes the further apart they are
- if crossing over happens more often, there should be more recombinants (*i.e.*, offspring that are different from the parents)
- so, we can tell how far apart two genes are from the crossing over frequency
- we set 1% crossing over frequency = 1 map unit

e.g., A fly with black body and notched wings is crossed with one having grey body and straight wings. The offspring are described in the table below:

black body, notched wings	43%	same as parents
grey body, straight wings	51%	
black body, straight wings	4%	different from parents (*i.e.*, recombinants)
grey body, notched wings	2%	

How far apart are the two genes?

$$\text{crossover \% (recombination frequency)} = \frac{\text{\# recombinant offspring}}{\text{total offspring}}$$

e.g., crossing over between genes three genes (A, B, and C) occur as follows:

A - B 12%
B - C 7%
A - C 5%

] these are the recombination frequencies

Maybe
A is body color
B is wing shape
C is antenna length

- remember that these are the results of three separate crosses.

Cross 1

Cross 2

Cross 3

- in each cross we would count the offspring that look different from the parents

3 possibilities exist

25. What does it mean if we say genes are linked? Which law of inheritance do linked genes violate?

26. How are crossover frequencies used to make chromosome maps.

27. What causes incomplete linkage?

28. Why are there more males with sex-linked genetic disorders than females?

29. In humans, which parent determines the sex of the offspring? Explain.

30. While examining a population of fruit flies, you notice that a certain trait never appears in males. How can you account for this?