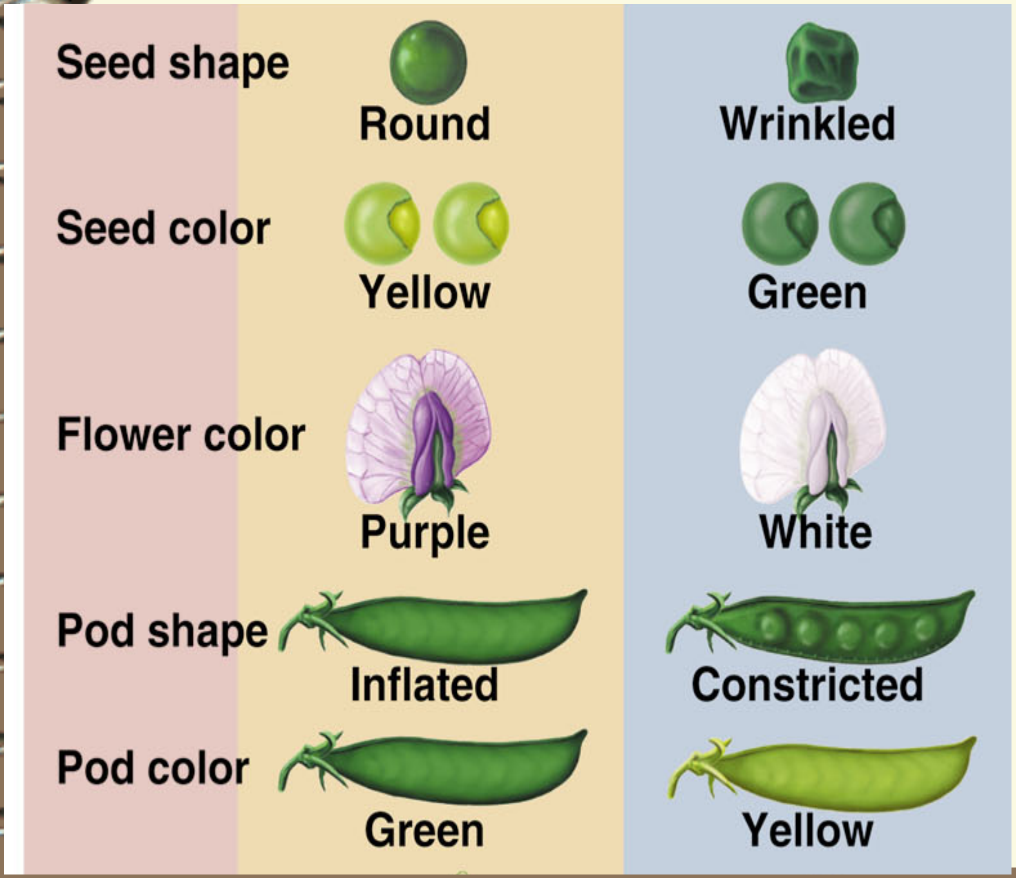
- Topic 3: Genetics
  3.4 Inheritance

Mendel's Work With Pea Plants

- Mendel discovered the principles of inheritance with experiments in which large numbers of pea plants were crossed.

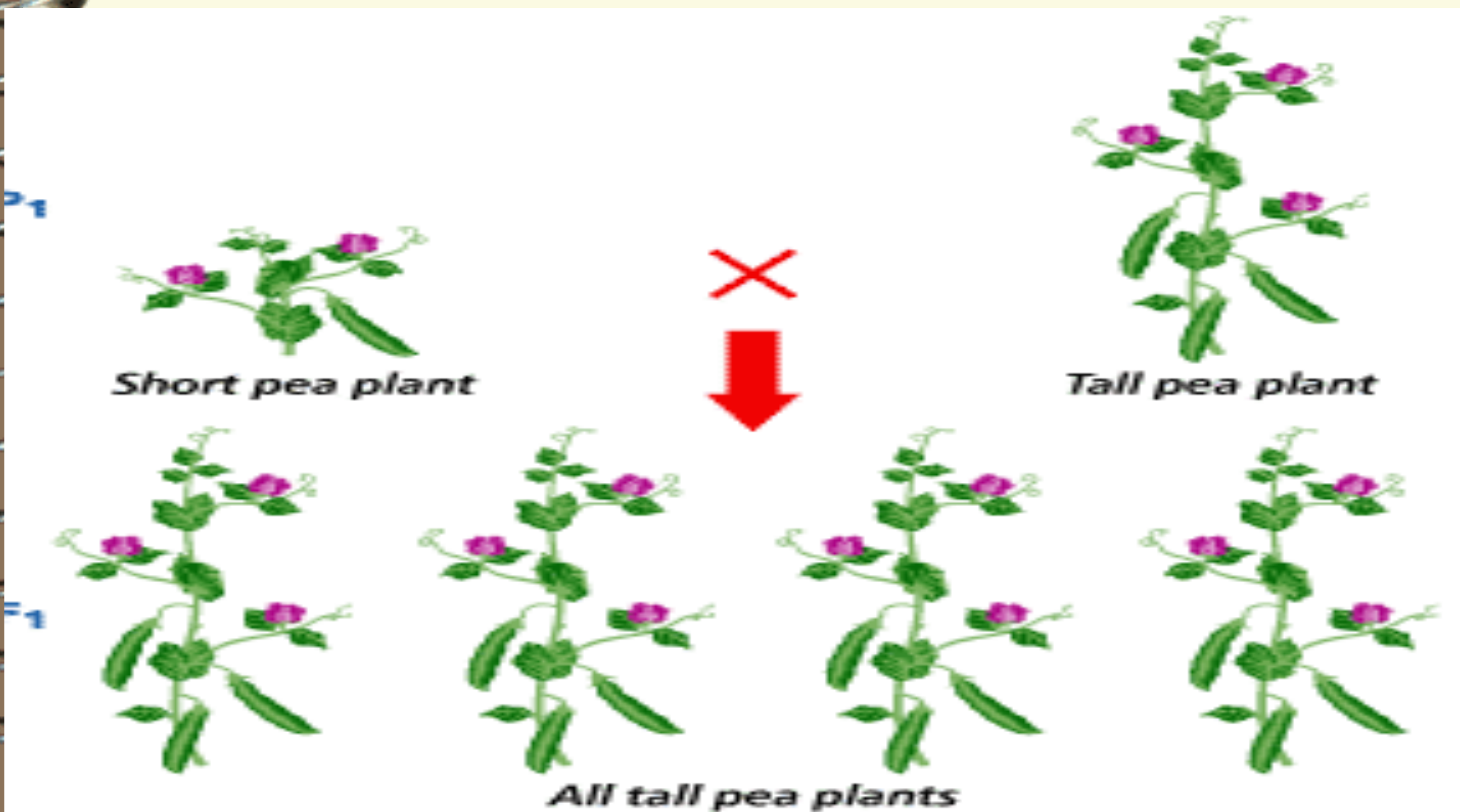


Mendel's crosses

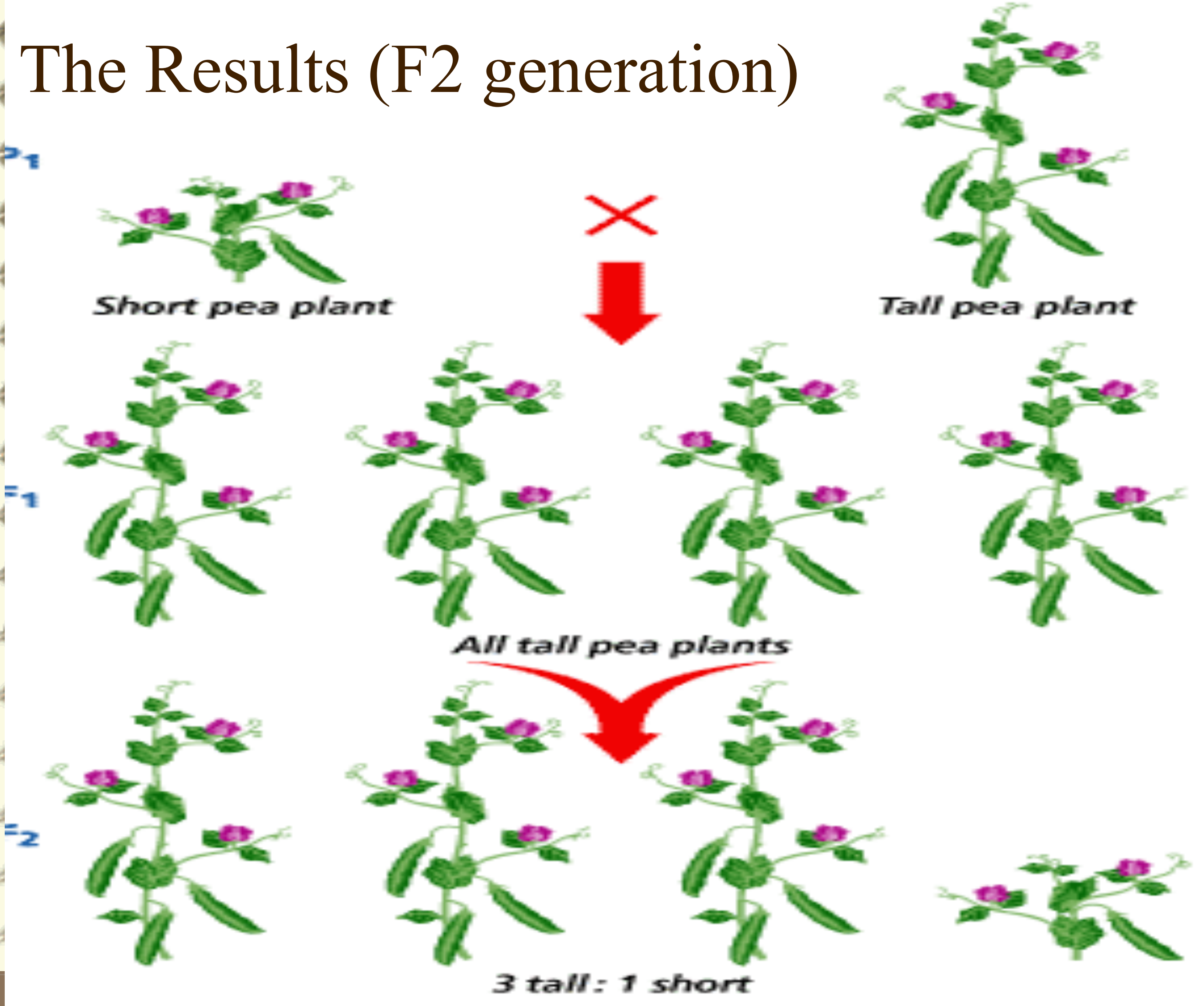
- **True-breeding/true bred (all offspring of same variety)**
- **Hybridization (crossing of 2 different true-breds)**

Example cross: What do you think the offspring will look like?

The Results (F1 generation)

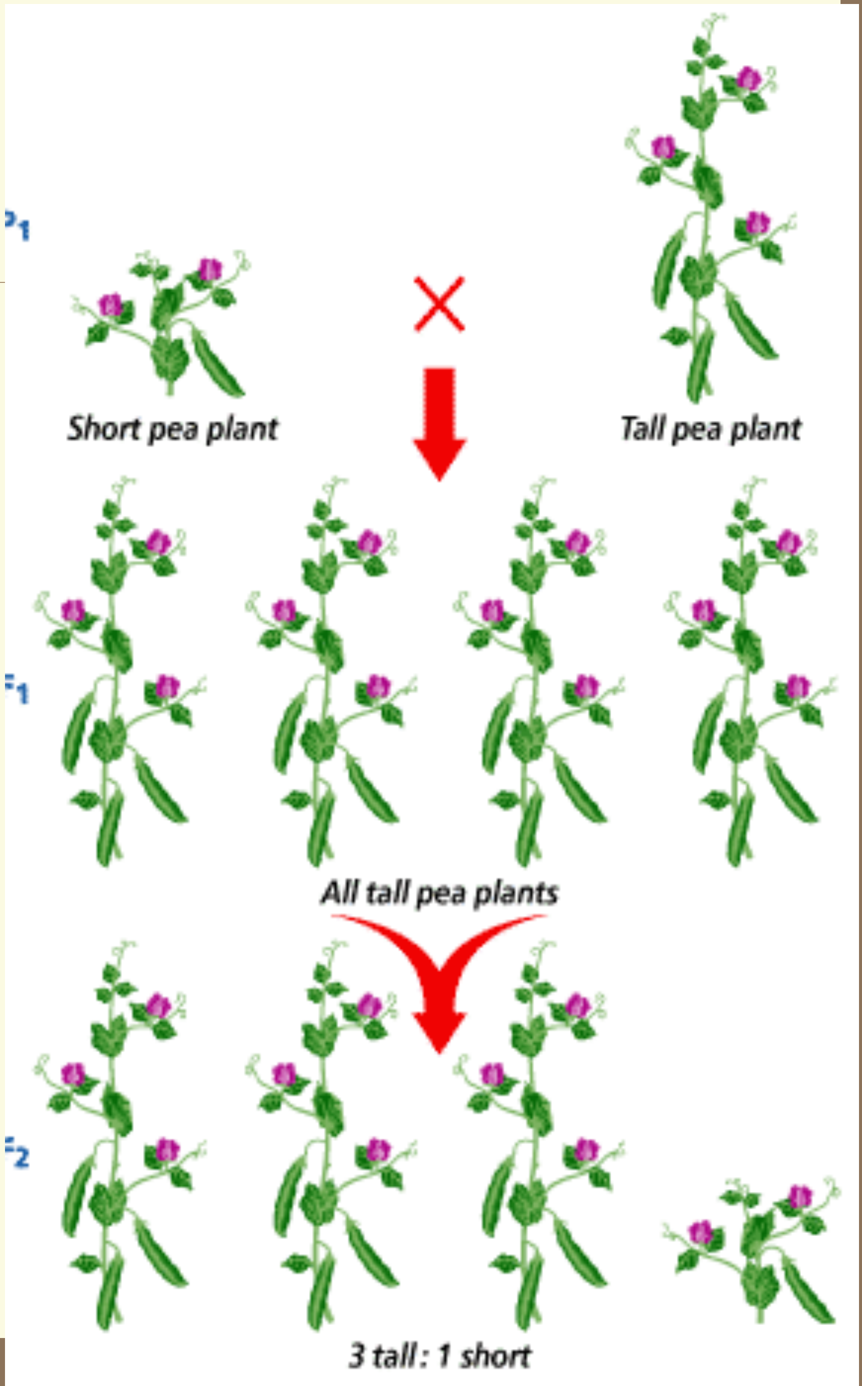


The Results (F2 generation)



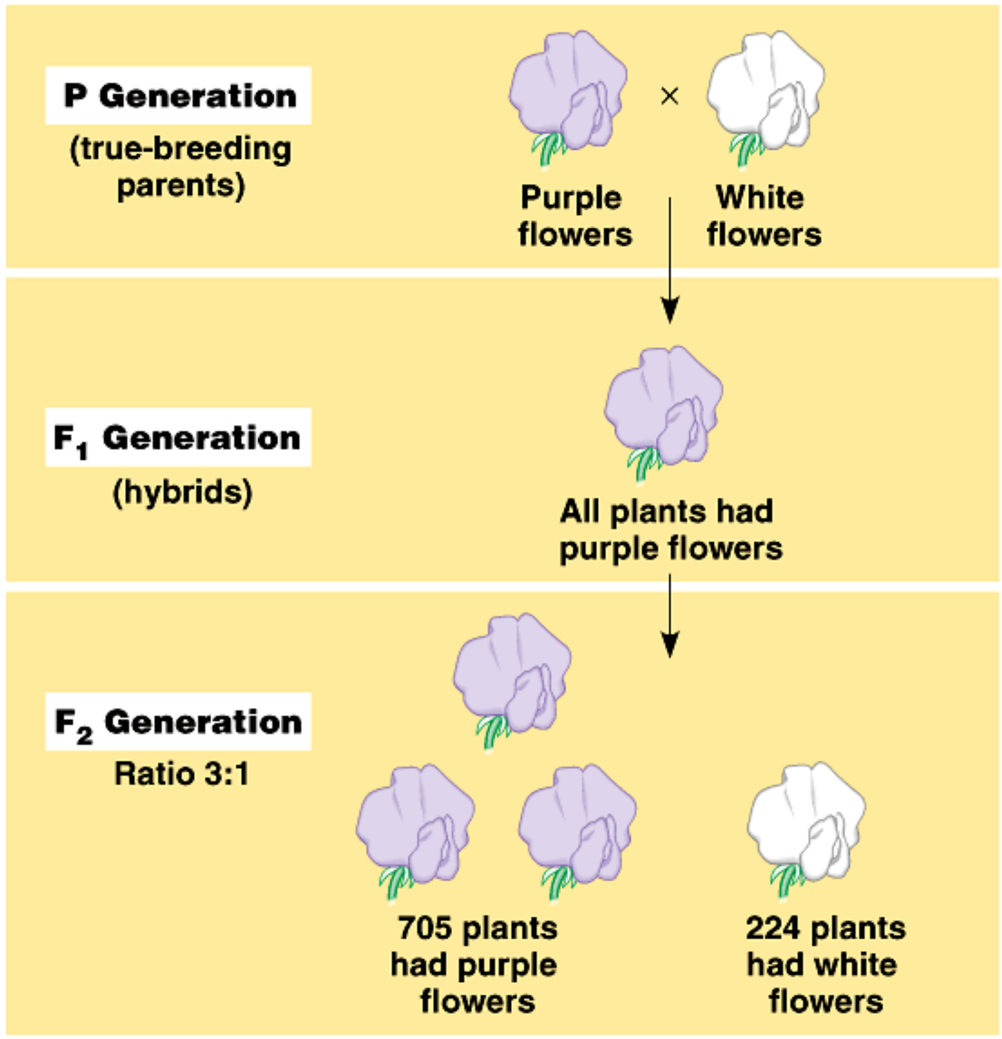
Generations

- Notice that Mendel looked at 3 generations in his crosses.
- Generations:
  - P = the original Parents (true-breeding)
  - F_1= the offspring of the P generation (hybrids)
  - F_2 = the offspring of the F_1 generation



Mendel's experiments

- Resulted in predictable ratios (notice the pattern)



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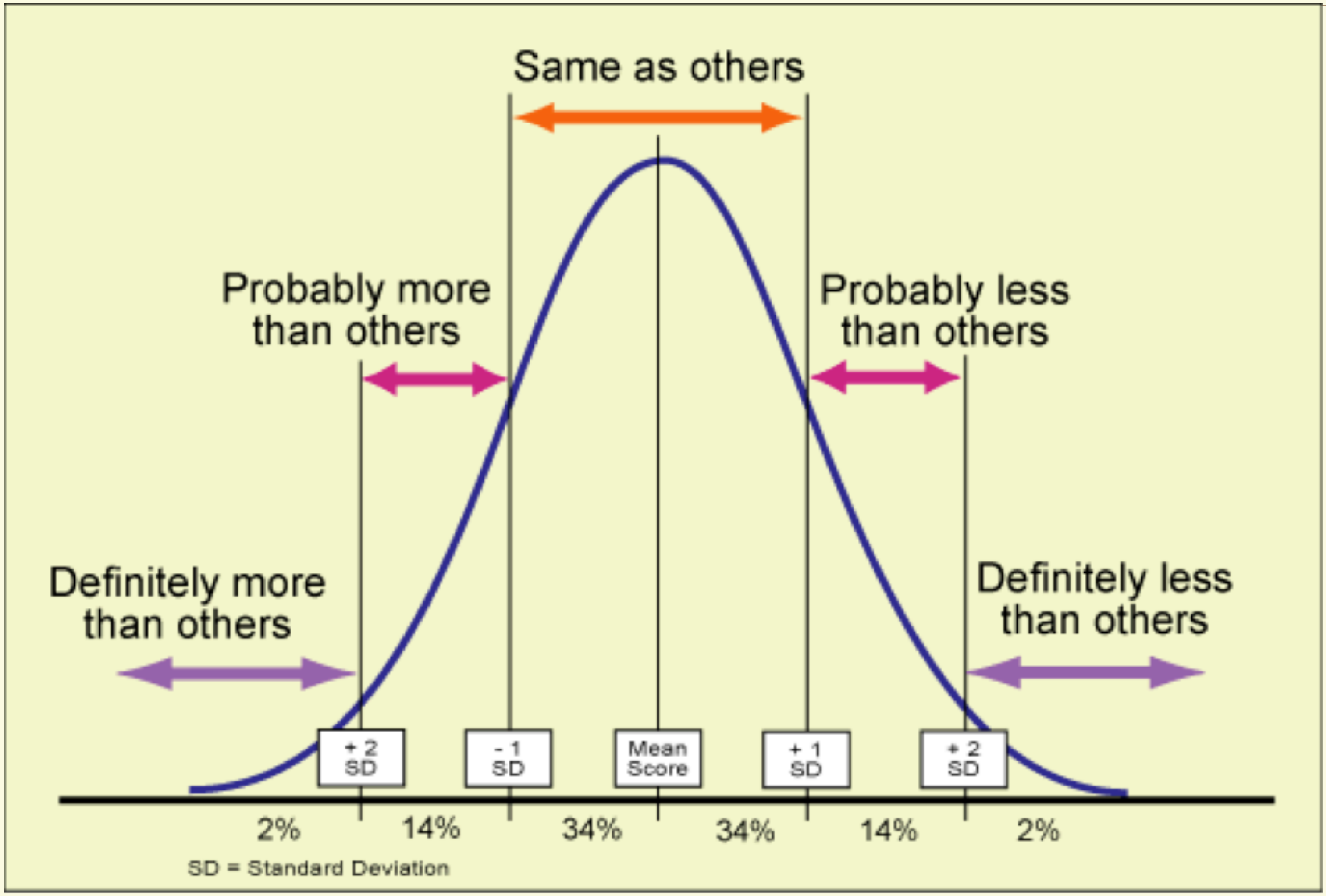
Nature of science:

- Making quantitative measurements with replicates to ensure reliability. Mendel’s genetic crosses with pea plants generated numerical data. (3.2)

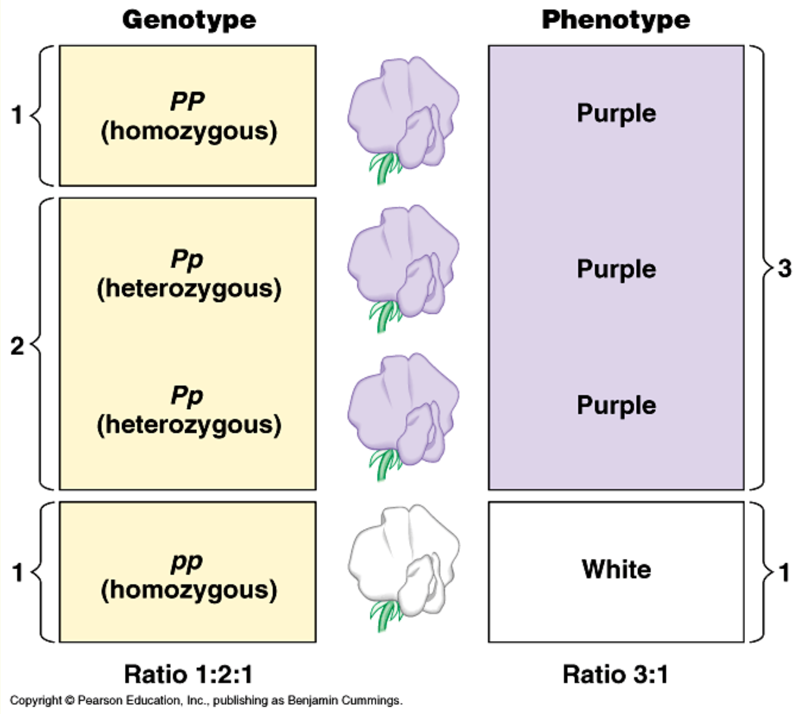
8 years and 1000s of test crosses before publishing results.

Why do multiple trials?



Genetic vocabulary…….

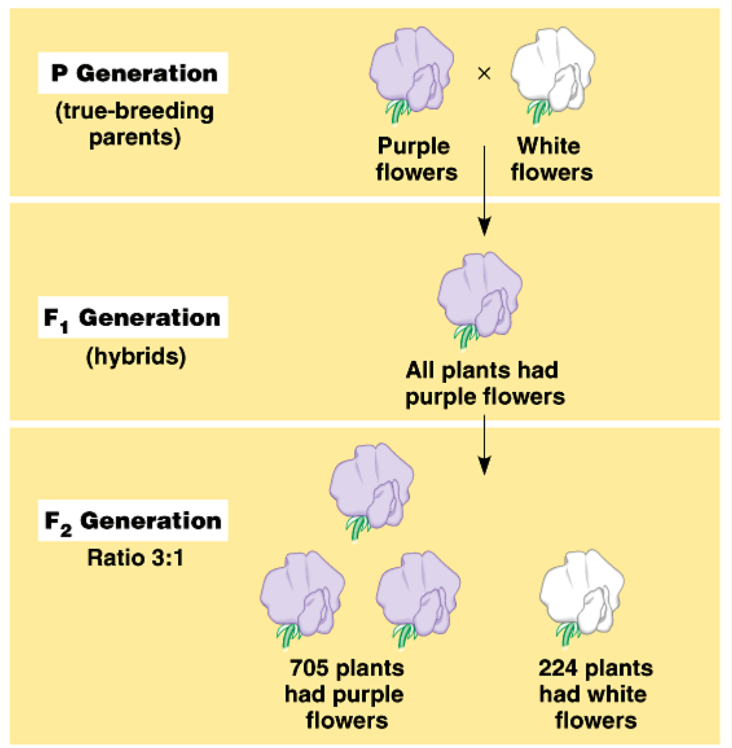
- Punnett square: predicts the results of a genetic cross between individuals of known genotype
- Homozygous: pair of identical alleles for a character
- Heterozygous: two different alleles for a gene
- Phenotype: an organism's traits
- Genotype: an organism's genetic makeup



Genetics vocab…

- dominant allele= fully expressed in the organism's appearance
- recessive allele, has no noticeable effect on the organism's appearance

- Testcross: A technique breeders use to determine the genotype of an unknown individual.
  – Done by crossing the unknown with a recessive homozygote.



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How to solve genetics problems

- READ and Make a Key ex. B= black fur, b= white fur
- Parent genotypes (Write them down) ex. BB x Bb
- Gametes (Figure out what the gametes would be)
- Fill in Punnett square to get offspring
- Phenotypes/Genotypes of offspring (Write them out)– Best if written as a reduced fraction!

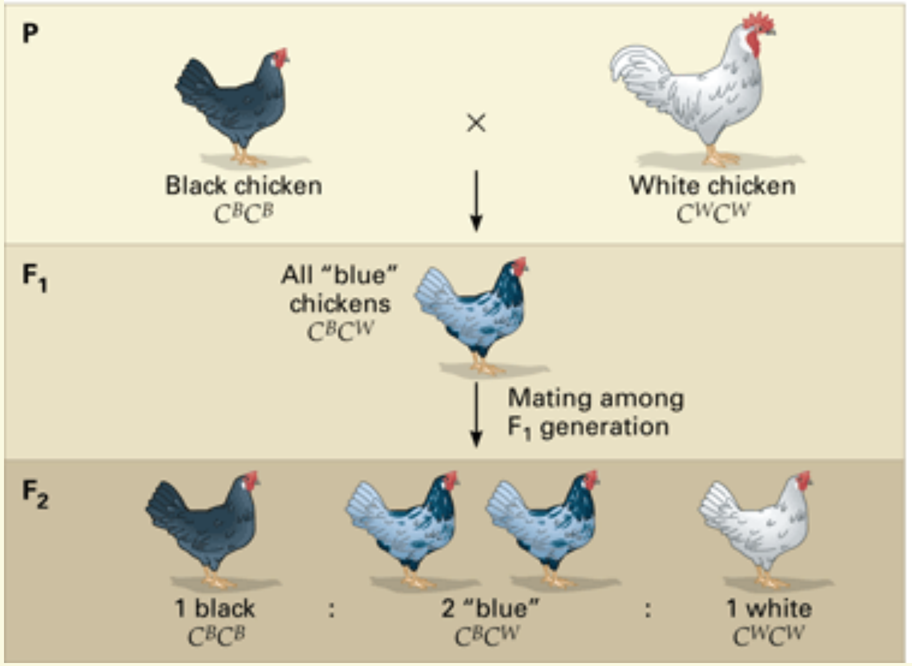
Practice Genetics problems #1-5 (see sheet)

Beyond Mendelian Genetics: Incomplete Dominance

- Mendel was lucky! Traits he chose in the pea plant showed up very clearly…
- One allele was dominant over another, so phenotypes were easy to recognize.
- But sometimes phenotypes are not very obvious…

Incomplete Dominance

- Neither allele is completely dominant over the other. The result is a THIRD possible phenotype.
- Two alleles that are incompletely dominant will result in an "AVERAGED" phenotype.



Incomplete Dominance

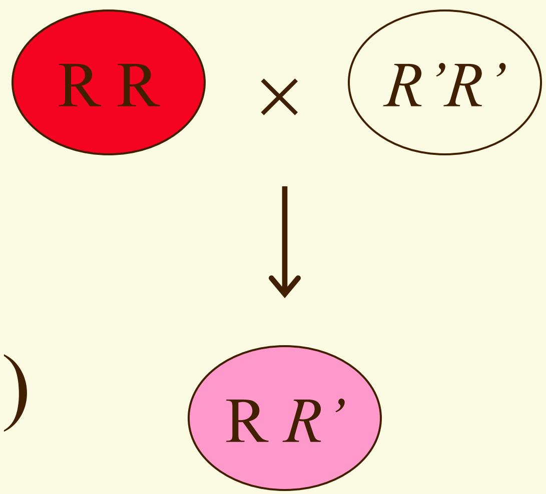
- Notation – Letters to represent alleles are capital letters with superscripted letter or (‘) to illustrate that neither allele is completely dominant.

- F^RF^W or FF’

Incomplete Dominance

- Snapdragon flowers come in many colo

- If you cross a red snapdragon (RR) with a white snapdragon (R'R')

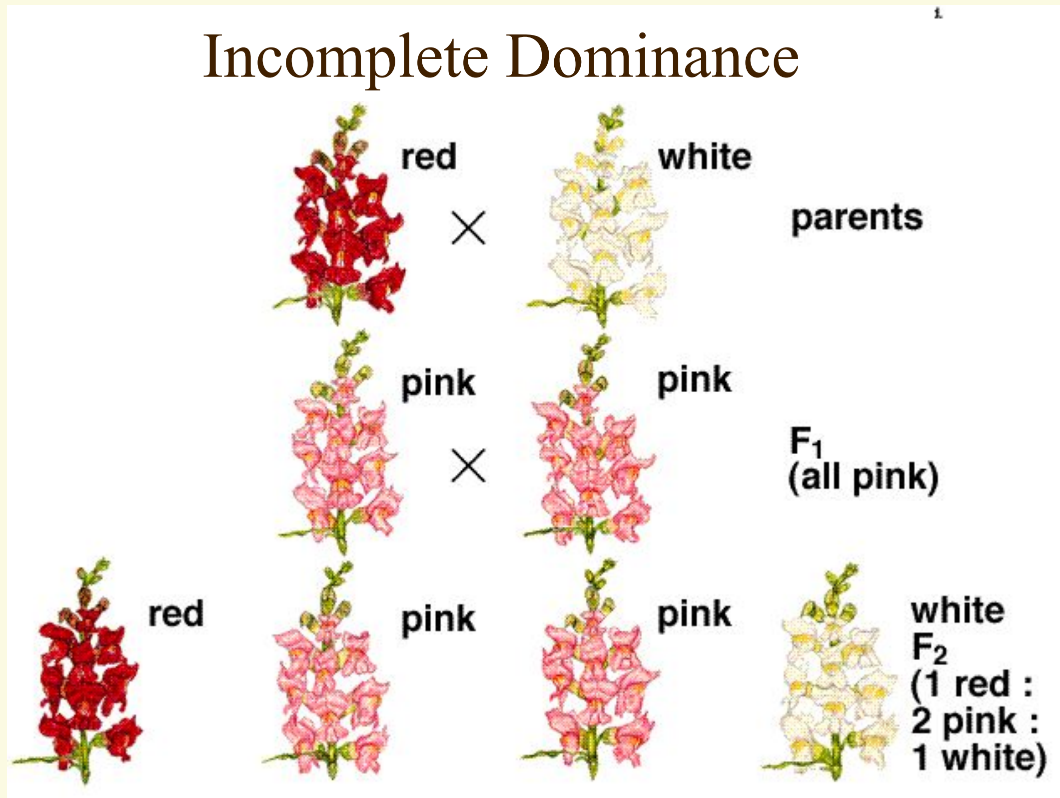


- You get PINK flowers (RR')

Incomplete dominance

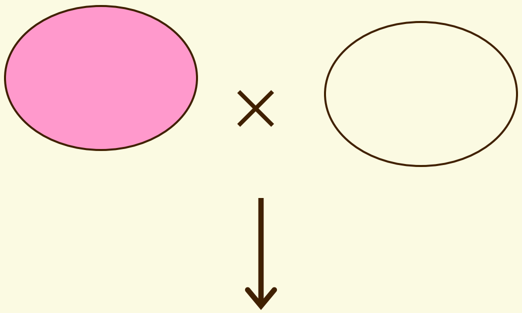
When F1(children) generation (all pink flowers) is self pollinated, the F2 (grandchildren) generation is 1:2:1 red, pink, white

	R	***R'***
R	**R R**	**R *R'***
R'	**R *R'***	***R'R'***

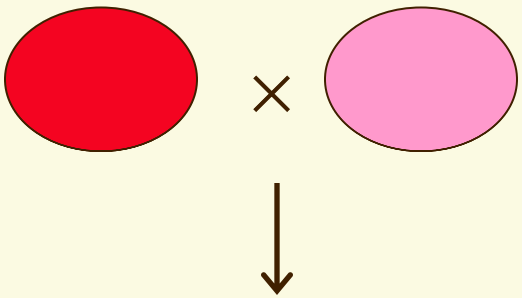


Incomplete dominance

What happens if you cross a pink with a white?



A pink with a red?



Dragon Genetics

- Let's assume that dragons show incomplete dominance for fire breathing. The F allele provides lots of fire and the F' allele gives no fire. If a dragon that has very strong fire is crossed with a dragon that has moderate fire, what will their offspring be like?

Dragon Genetics

- Under what conditions can a baby dragon be born that never has fire? Justify your answer with Punnett Squares.

Complex Trait: Hagrid's Height

- Hagrid's father was a wizard and his mother was a giantess. The normal heights for giants and wizards are: Giants = about 20 ft. & Wizard = 5-6 ft.
- Given that Hagrid is described to be about 12 ft., what type of genetic inheritance may be at work for Hagrid's height?

Codominance

- Both alleles are expressed at the same time.
- Notation = Two different capital letters

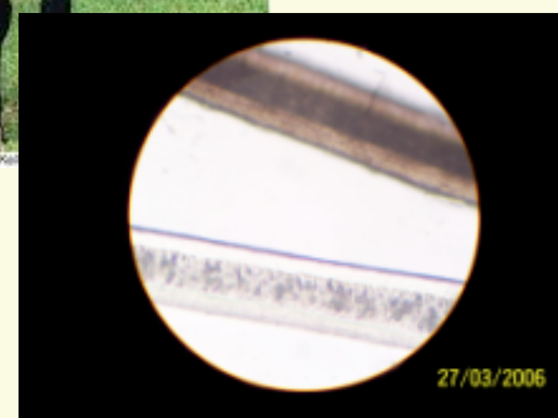
  RW
- Or one capital letter with two different superscripts

  $R^W R^T$

Codominance

- Both alleles' traits are completely expressed independently.

"Blue Roan"



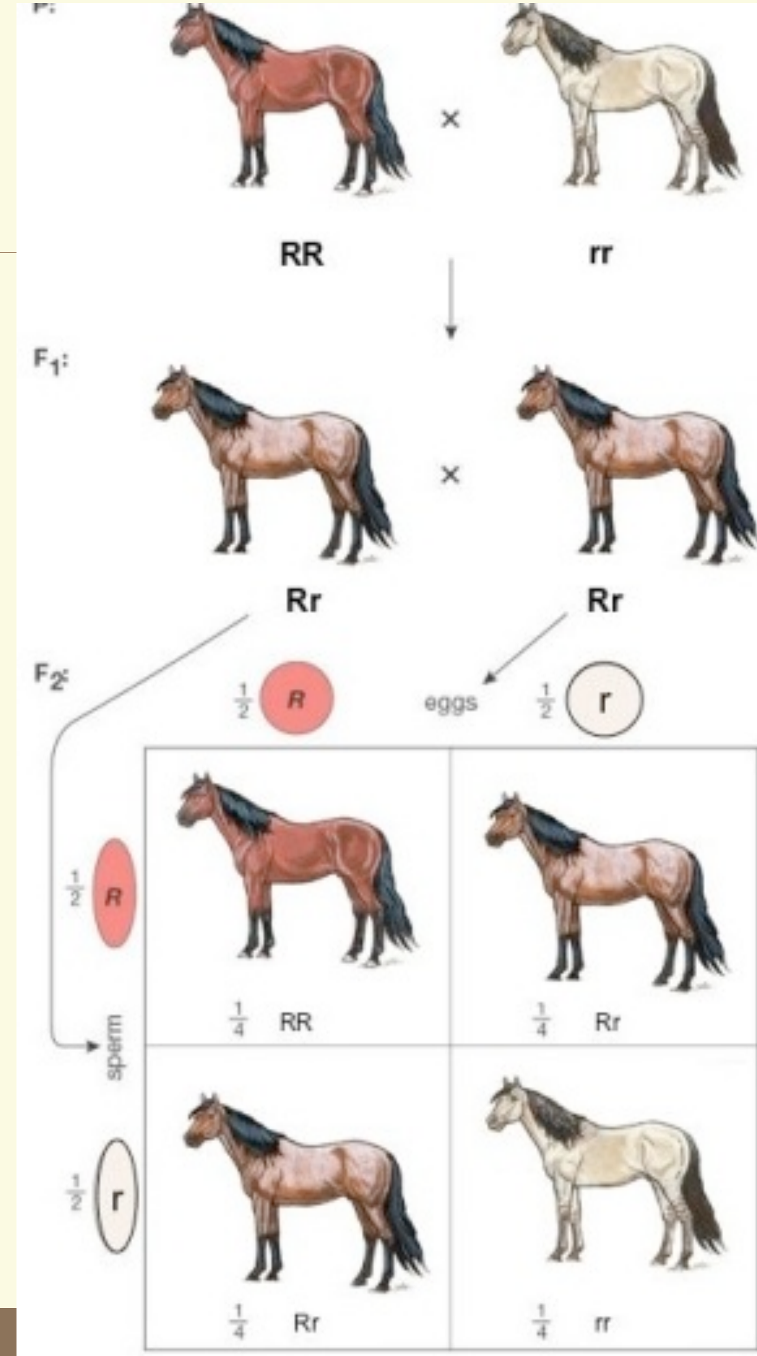
RR × WW

	R	R
W	RW	RW
W	RW	RW

Black X White = 100% Blue Roan

Roan X Roan =
25% Black
25% White
50% Roan

	B	W
B	BB	BW
W	BW	WW



Codominance

- The color of merpeople's tail is controlled by a codominant gene and the alleles are blue (B) and green (G). Show a cross between two merpeople who have bluish-green tai (BG). Give the offspring phenotypes with percentages.

Complex Trait: Harry's Eyes

- Eye color in humans has multiple alleles:
  - **B** = brown (codominant with green)
  - **G** = green (codominant with brown)
  - **b** = blue (recessive to both brown and green)
- Draw a Punnett Square with Harry's parents: assuming Lily with green eyes (**GG**) and James with hazel eyes (**BG**).

Incomplete Dominance

Codominance

Complex-Trait Activity: Magical Ability

In the *Harry Potter* series, characters are born with or without magical ability. Those with magical ability also show very strong, normal or weak ability.

Assuming that the magical ability is inherited, identify the possible phenotypes and genotypes of the following characters: Harry, Hermione, Ron, Dumbledore, Aunt Petunia, and Mr. Filch

Magical Ability: Possible Phenotypes

How would you describe the following characters' magical ability?

- Harry
- Hermione
- Ron
- Dumbledore
- Aunt Petunia
- Mr. Filch

Magical Ability: Possible Phenotypes

How would you describe the following characters' magical ability?

- Harry has strong magical ability
- Hermione has strong magical ability
- Ron has average magical ability
- Dumbledore has strong magical ability
- Aunt Petunia has no magical ability
- Mr. Filch has weak magical ability

Two Genes that regulate magical ability

Expression—has the ability or doesn't have the ability

Strength—has strong, average, or weak magical ability

Magical Ability: Possible Genotypes

Gene 1: expression of magical ability

Expressed (witches & wizards)

Not expressed (Muggles do not have magical ability)

Gene 2: strength of magical ability

Strong

Average

Weak (i.e., squibs)

Magical Ability: Possible Genotypes

- Two Muggle parents can have a child with magical ability, like Hermione➔ Muggles must have a gene for magic that is not expressed or silenced by another regulatory gene.

- The possible alleles for the silencing gene are: **N (dominant)** or **n (recessive)**.

Expressed (witches & wizards) **—nn**

Not expressed (Muggles) **—NN, Nn**

Magical Ability: Possible Genotypes

- There are three phenotypes described for the strength of magical ability: strong, average, or weak.

- Given “strong + weak=average”, the magical strength gene with **M (strong ability)** and **M’ (weak ability)** alleles affected by incomplete dominance.

Strong ability —**MM**
Average ability—**MM’**
Weak ability —**M’M’**

Magical Genes: Summary of 2 Genes

- Must be **nn** to have magical ability:
  - **MMnn** = very powerful wizard
  - **MM’nn** = average wizard
  - **M’M’nn** = very weak wizard (or squib)
- If you have at least one **N** you are a Muggle:
  - **MMNn**, **MM’Nn**, **M’M’Nn** (carrier for magic ability)
  - **MMNN**, **MM’NN**, **M’M’NN**

Magical Ability: Characters' Genotypes

Using the genotype summary, what are possible genotypes of each character?

- Harry: strong magical ability
- Hermione: average magical ability
- Ron: average magical ability
- Dumbledore: strong magical ability
- Aunt Petunia: no magical ability
- Mr. Filch: weak magical ability

Magical Ability: Characters' Genotypes

Using the genotype summary, what are possible genotypes of each character?

- Harry: strong magical ability **(MMnn)**
- Hermione: average magical ability **(MMnn)**
- Ron: average magical ability **(MM'nn)**
- Dumbledore: strong magical ability **(MMnn)**
- Aunt Petunia: no magical ability **(MMNn, MM'Nn, M'M'Nn, MMNN, MM'NN, M'M'NN)**
- Mr. Filch: weak magical ability **(M'M'nn)**

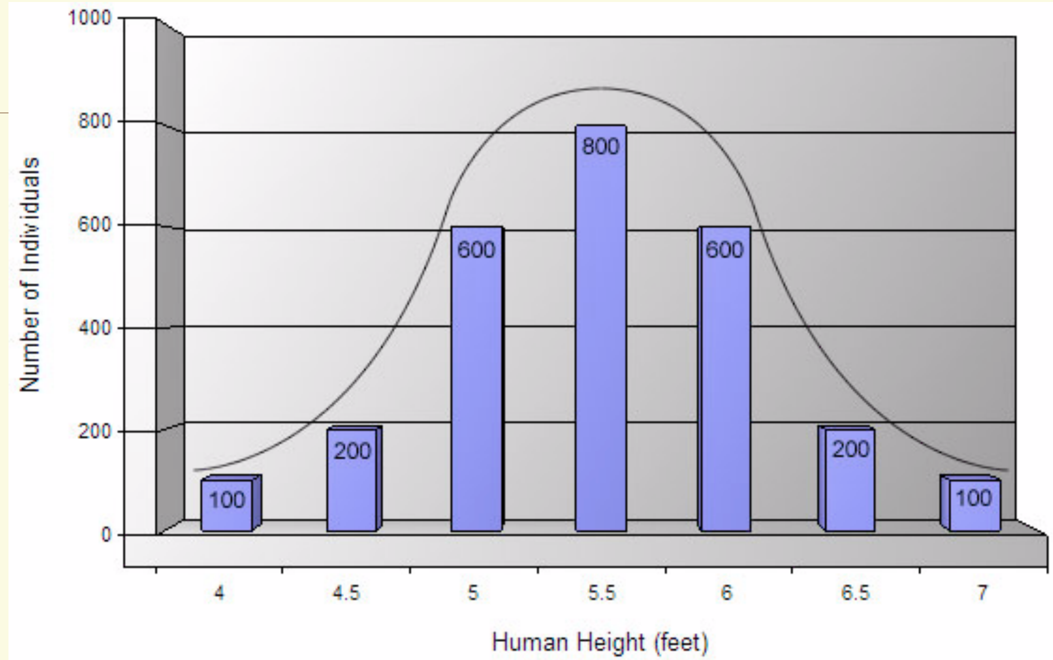
Think it through….

- Hermione's possible genotypes are MMss or MM'ss. What are possible genotypes of Hermione's parents who are Muggles?

Important Law of Probability

- The probability of 2 (or more) independent events occurring together can be obtained by multiplying the probability of one event by the probability of the other.
- Note: This can also be used to solve dihybrid cross problems!

Polygeneic Inheritance



Gene 1	d^1d^1	d^1D^1	d^1D^1	D^1D^1	D^1d^1	D^1d^1	D^1D^1
Gene 2	d^2d^2	d^2d^2	d^2D^2	D^2d^2	D^2d^2	D^2D^2	D^2D^2
Gene 3	d^3d^3	d^3d^3	d^3d^3	d^3d^3	D^3D^3	D^3D^3	D^3D^3
Total number of dark-skin genes	0	1	2	3	4	5	6

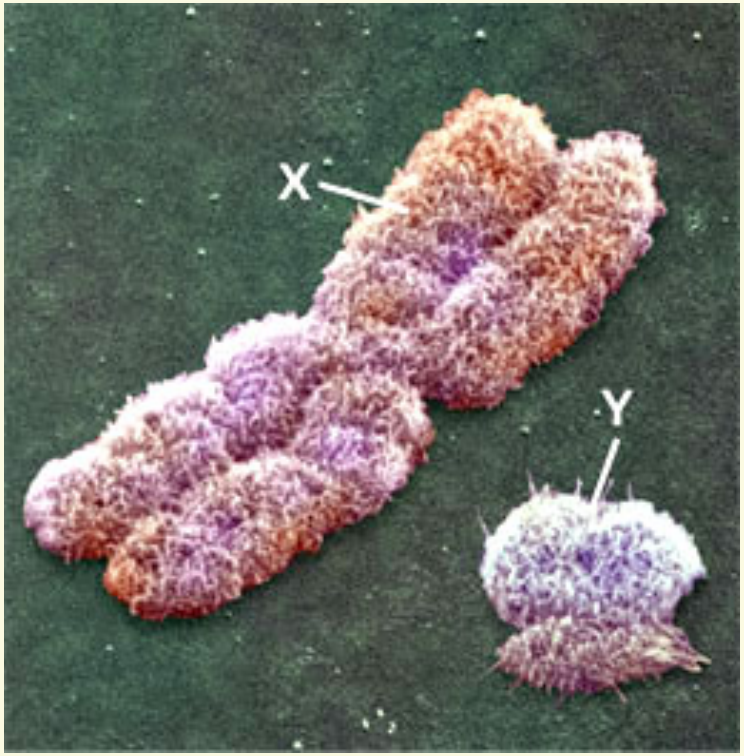
	Very light			Medium			Very dark
# of light "d" alleles	6	5	4	3	2	1	0
# of dark "D" alleles	0	1	2	3	4	5	6

FIGURE 10.7 **Polygenic Inheritance**
Skin color in humans is an example of polygenic inheritance. The dark "D" alleles are found in several different genes and have an additive effect on skin color. The top portion of the figure shows examples of genotypes that can produce the different skin colors. The number of dark "D" alleles is more important than how the "D" alleles are distributed in the different genes.

The alleles are cumulative.
Therefore, AaBbCc has the same phenotype as AABbcc

Sex Link Traits:

Genes on the X and Y chromosomes



Lets recall how we determine gender…

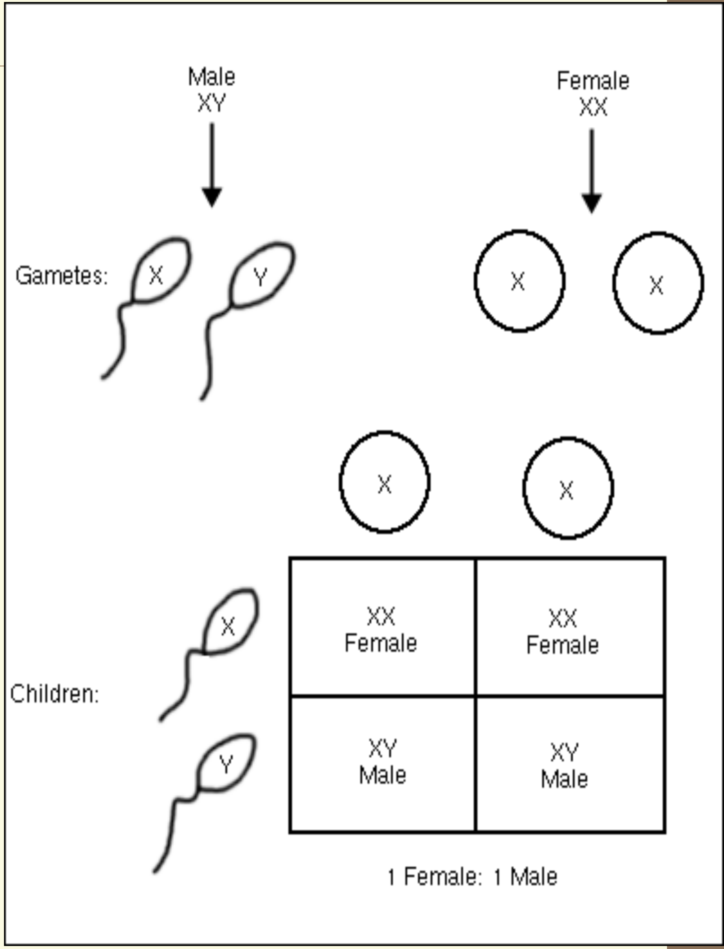
How do we determine the sex of an individual?

- Sex Chromosomes: X and Y

  Female: XX   Male: XY

- Who is responsible for gender determination in the child?

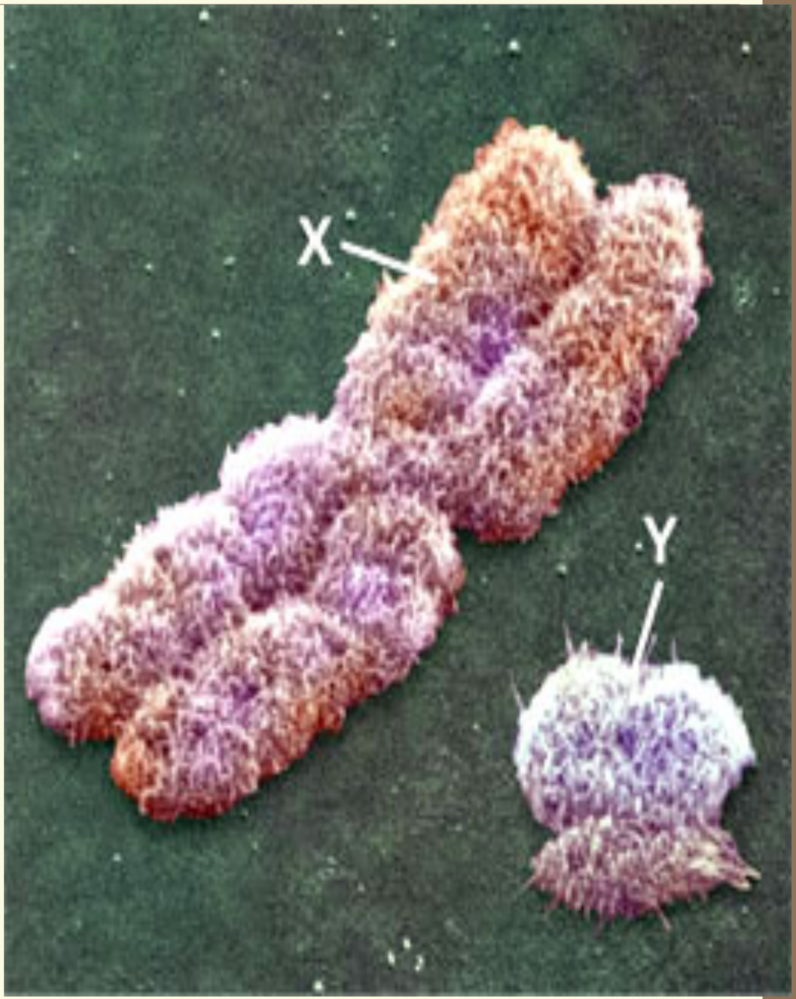
  The father because he gives an X or Y to the gametes. The mother only gives an X to the gamete



What are sex-linked genes?
→ genes found on a sex chromosome

- X-linked genes are genes found on the X chromosome, symbolized by X^r, X^R, Y.

- Thomas Morgan experimented with the eye color of fruit flies (Drosophilia) to determine X-linkage



X-linked Genes

- X-linked recessive traits will show up more often in males because they have only 1 X chromosome
- Let's do a punnett square for a female carrier of an x-linked gene and a recessive male
- What will the genotypes be?
  - X^RX^r and X^RY

Here's the results

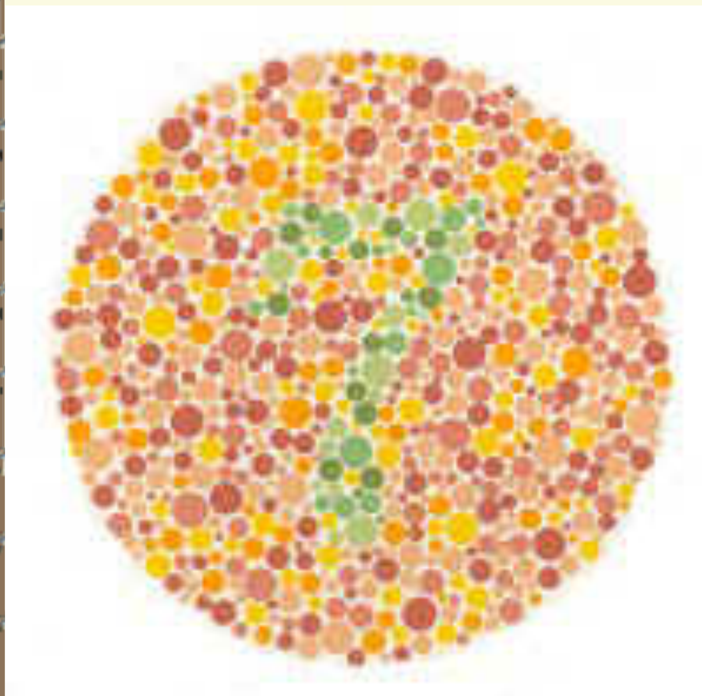
- For girls: 0% have the trait
- For boys 50% have it.
- Probability is higher for boys because whatever X they get determines the trait, for girls they have to get 2 recessive X's.

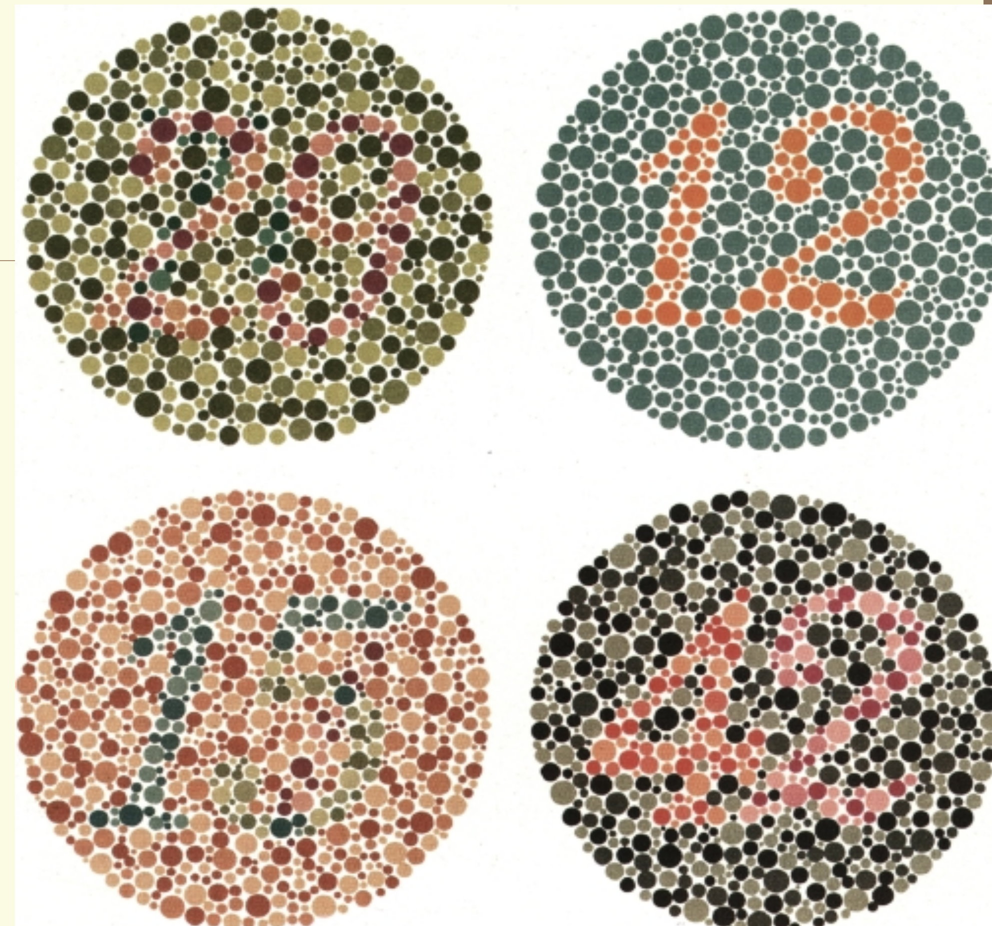
	X^R	X^r
X^R	$X^R X^R$	$X^R X^r$
Y^0	$X^R Y^0$	$X^r Y^0$

Examples of X-linked traits:

1. Color Blindness
2. Hemophilia
3. Muscular Dystrophy
4. Icthyosis simplex (scaly skin)

Colorblindness





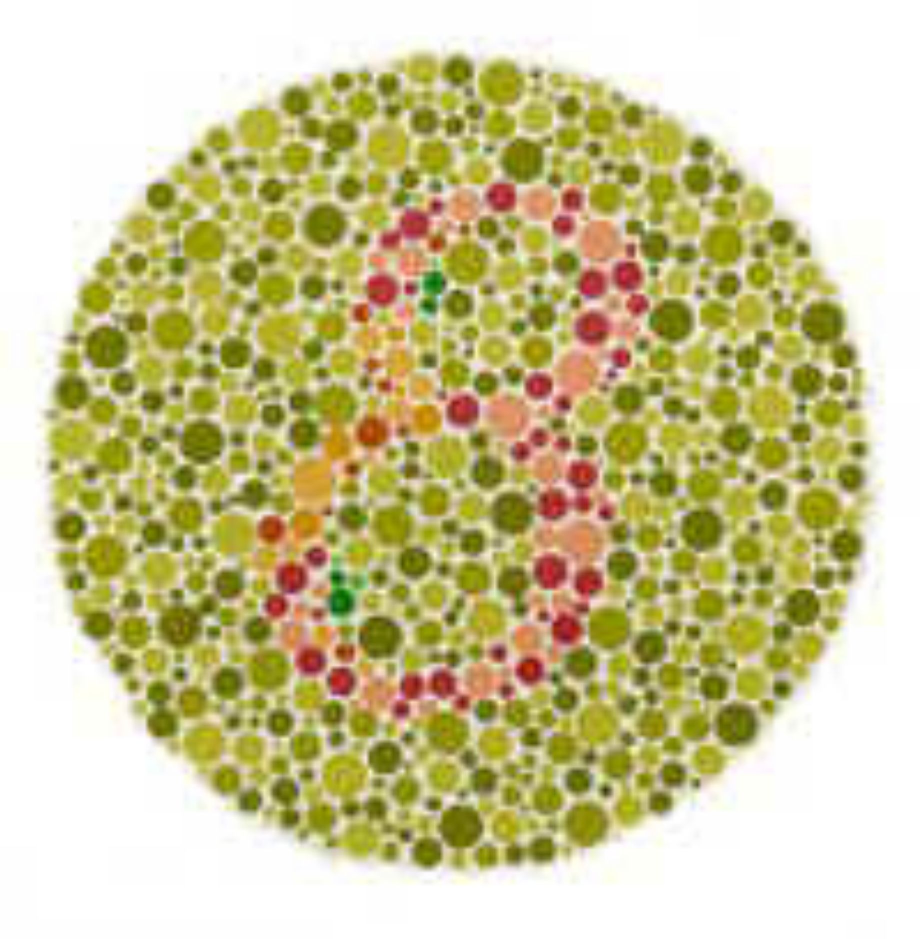
- A person with normal color vision sees a number seven in the circle above.
- Those who are color blind usually do not see any number at all.

Colorblindness

- RED-GREEN COLORBLINDNESS:

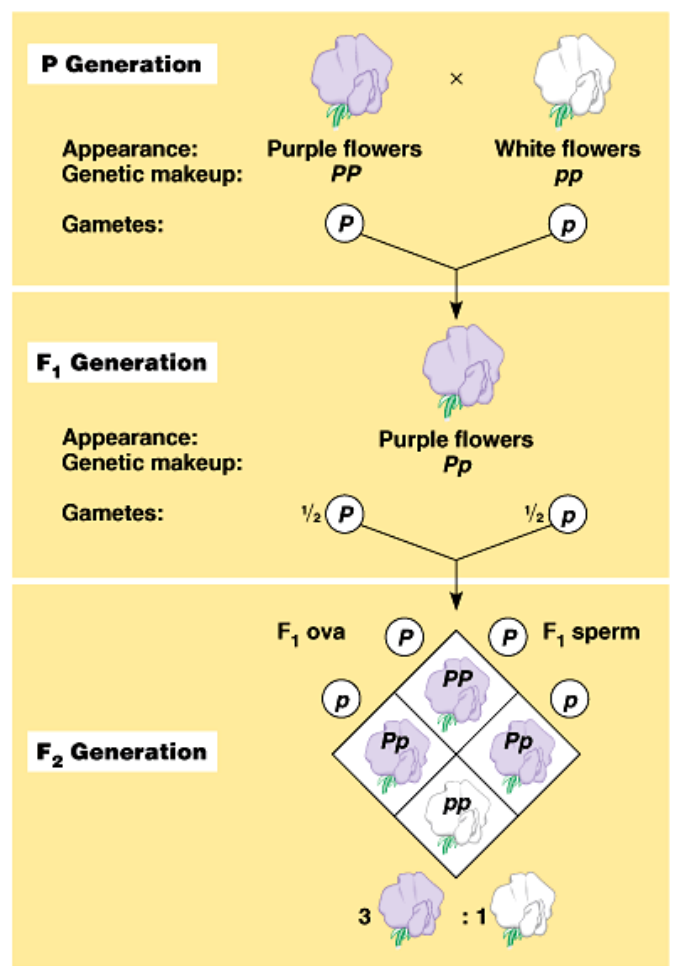
- People with red-green color blindness see either a three or nothing at all.

- Those with normal color vision see an 8.



The *Law of Segregation*

- For each character, an organism inherits 2 alleles, one from each parent
- Mendel's *Law of Segregation:* The alleles for each character segregate (separate) during gamete production (meiosis), then randomly re-form pairs during fusion of gametes at fertilization.



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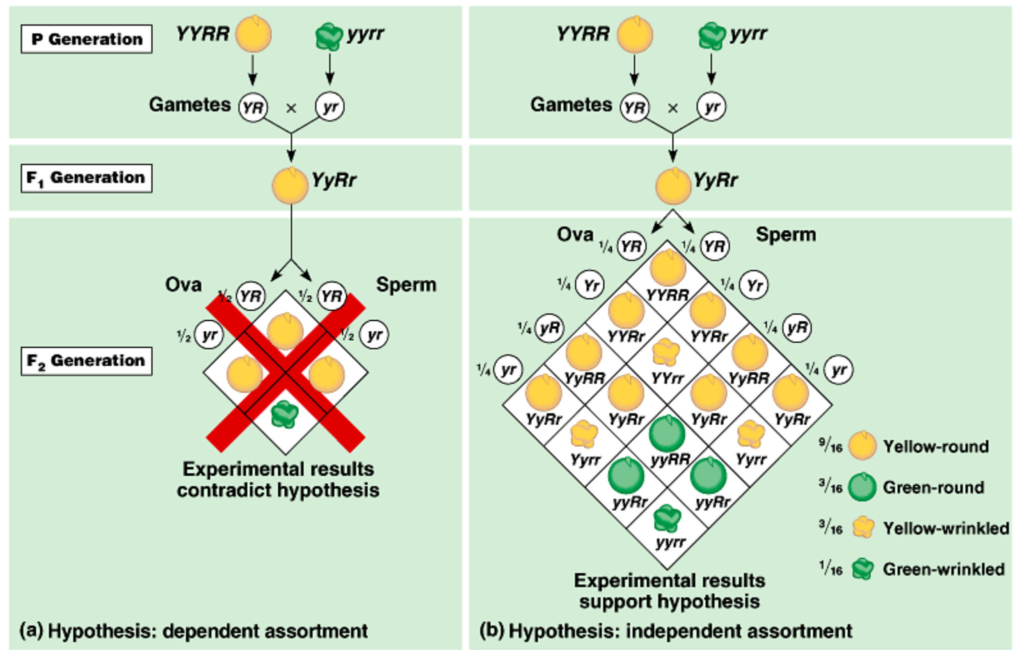
The *Law of Independent Assortment*

- Applies to dihybrid crosses…
- Mendel's *Law of Independent Assortment:* The two pairs of alleles segregate independently of each other during gamete formation.
- ***NOTE: True only when genes for the different traits are located on different chromosomes.***
- How does this relate to Meiosis?



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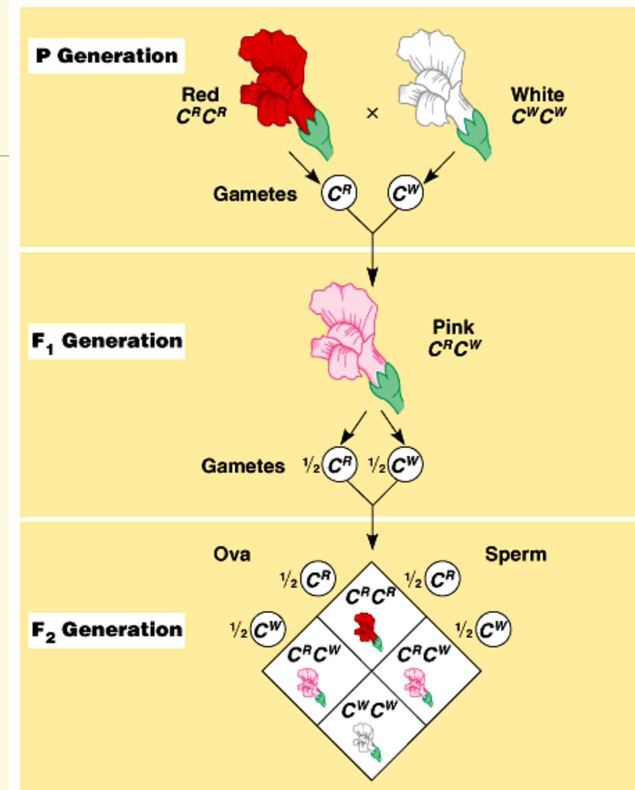
Other Inheritance Patterns

- ✓ ***Codominance***
- ✓ ***Multiple alleles***
- ✓ ***Sex-linked inheritance***
- ✓ ***Polygenic Inheritance***



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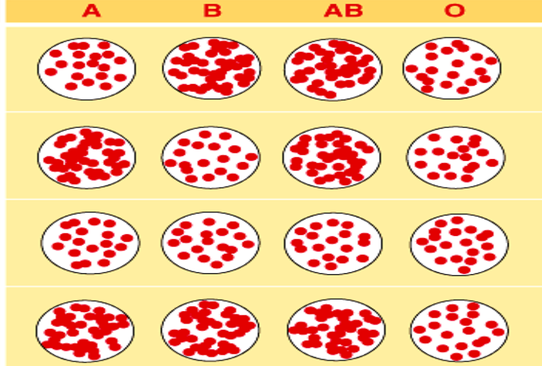
(a) Phenotype (blood group)	(b) Genotypes (see p.258)	(c) Antibodies present in blood serum	(d) Results from adding red blood cells from groups below to serum from groups at left			
			A	B	AB	O
A	$I^A I^A$ or $I^A i$	Anti-B				
B	$I^B I^B$ or $I^B i$	Anti-A				
AB	$I^A I^B$	—				
O	ii	Anti-A Anti-B				



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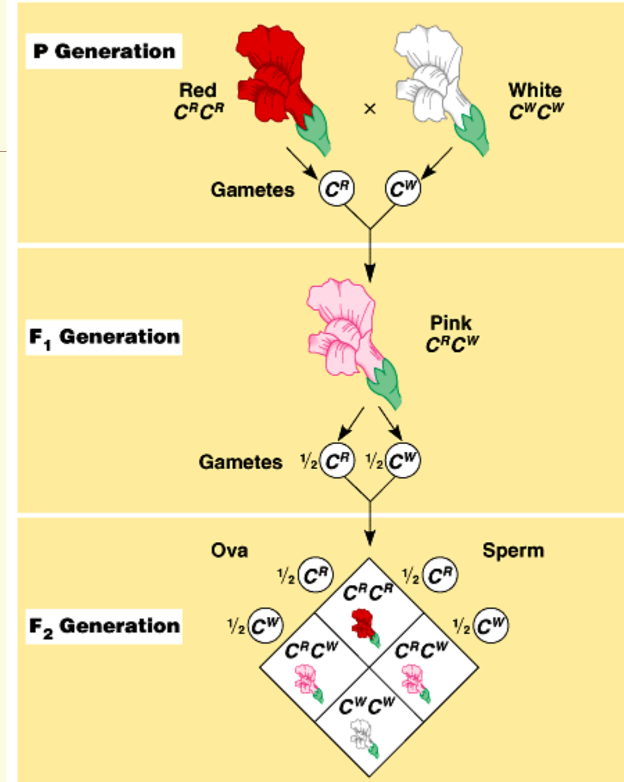
Incomplete dominance: appearance between the phenotypes of the 2 parents. (blending) Ex: pink snapdragons (no longer a distinction used by IB)

- *Codominance*: both alleles affect the phenotype of a heterozygote. Ex: blood types

- *Multiple alleles*: more than 2 possible alleles for a gene. Ex: human blood types



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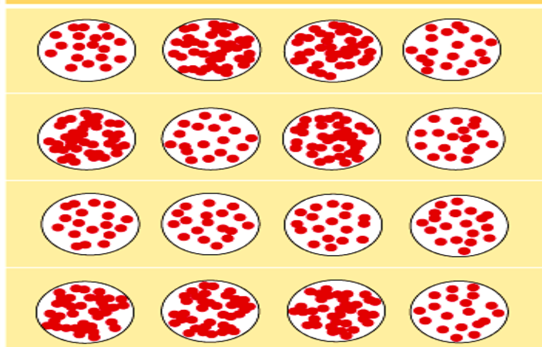
(a) Phenotype (blood group)	(b) Genotypes (see p.258)	(c) Antibodies present in blood serum	(d) Results from adding red blood cells from groups below to serum from groups at left: A	B	AB	O
A	I^AI^A or I^Ai	Anti-B				
B	I^BI^B or I^Bi	Anti-A				
AB	I^AI^B	—				
O	ii	Anti-A Anti-B				



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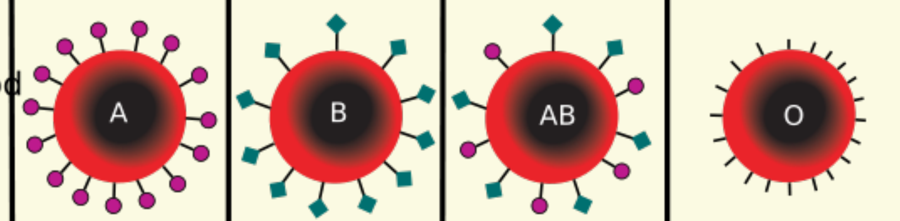
Incomplete dominance: appearance between the phenotypes of the 2 parents. (blending) Ex: pink snapdragons (no longer a distinction used by IB)

Application: Inheritance of ABO blood groups.

- ✓ Codominance with multiple alleles
- ✓ 3 Alleles: I^A, I^B, i

TYPES:

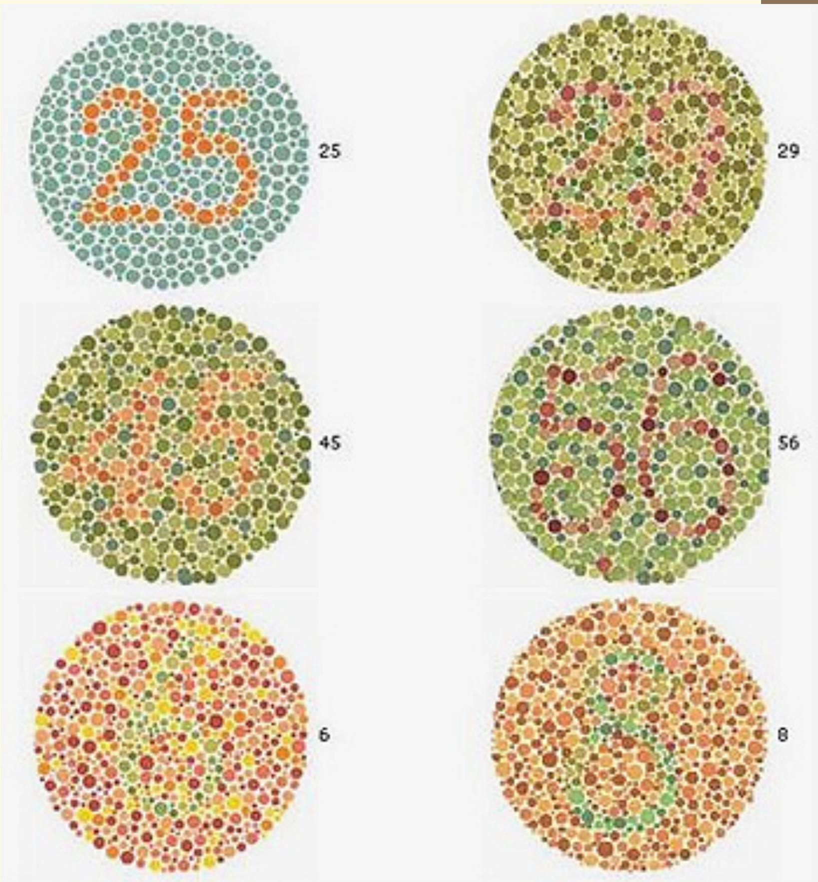
- A = I^AI^A, I^Ai
- B = I^BI^B, I^Bi
- AB = I^AI^B
- O = ii

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies present	 Anti-B	Anti-A	None	Anti-A and Anti-B
Antigens present	A antigen	B antigen	A and B antigens	None

Sex-Linked

- Gene is found on a sex chromosome (usually X)
- Trait more commonly seen in males.
  - Ex. Red-Green color blindness, hemophilia
- Possible genotypes
  - **Female=**
    - X^RX^R
    - X^RX^r
    - X^rX^r
  - **Male=**
    - X^RY
    - X^rY

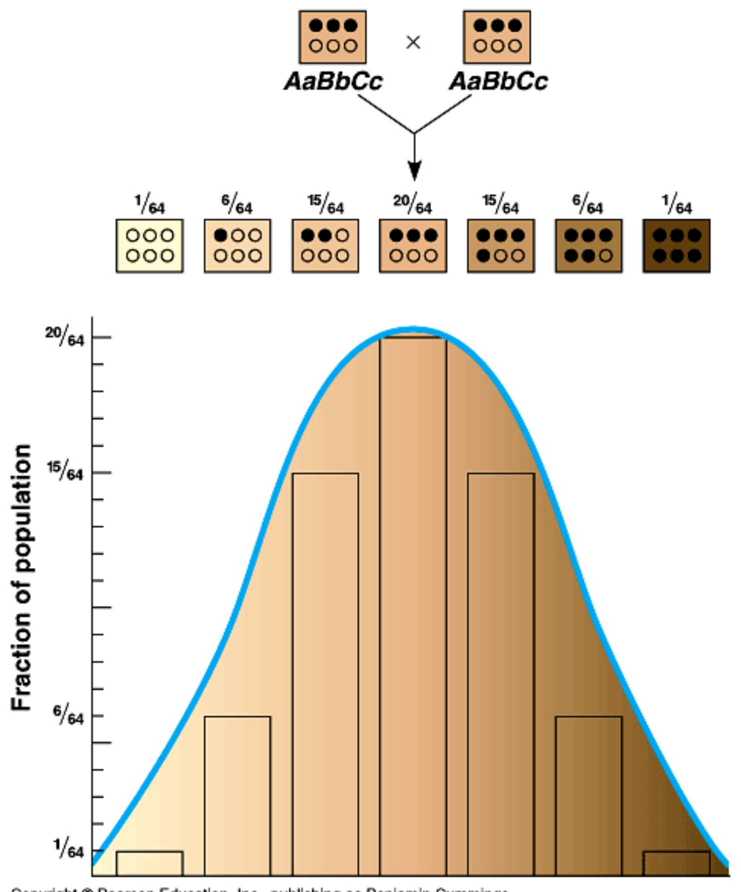
"Y" is empty



Fruit Flies bio powerpoints\Chapter 12 BDOL IC

- ✓ ***Polygenic Inheritance:*** **inheritance pattern where two or more genes affect a single characteristic. Ex: human skin pigmentation and height**

- ✓ The phenotypes of polygenic characteristics tend to show continuous variation.



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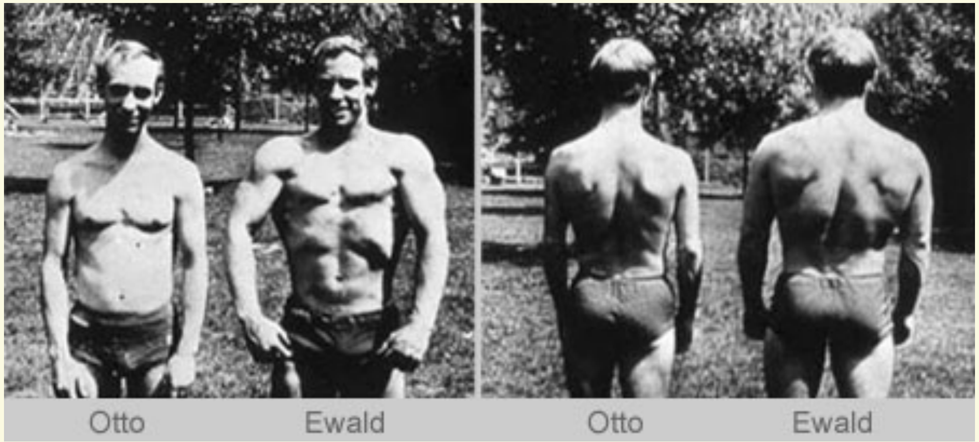
Application:

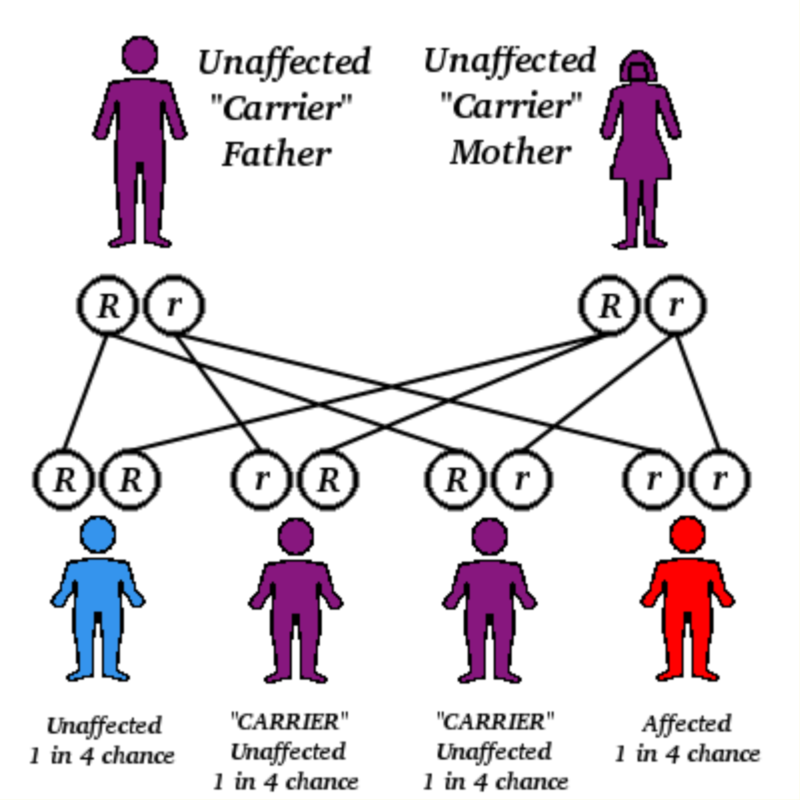
- Polygenic traits such as human height may also be influenced by environmental factors.
  - Examples: nutrition, exercise, sunlight exposure, etc.



- Practice genetics problems #11-15 (note: #11 is NOT sex-linked)
- Genetics Practice: Incomplete Dominance, Codominance, Multiple Alleles and Sex-Linked WS

Human genetic diseases

- Many have been identified but most are very rare.
- Many are due to recessive alleles of autosomal genes.
- Some are due to dominant or co-dominant alleles.
- Some are sex-linked

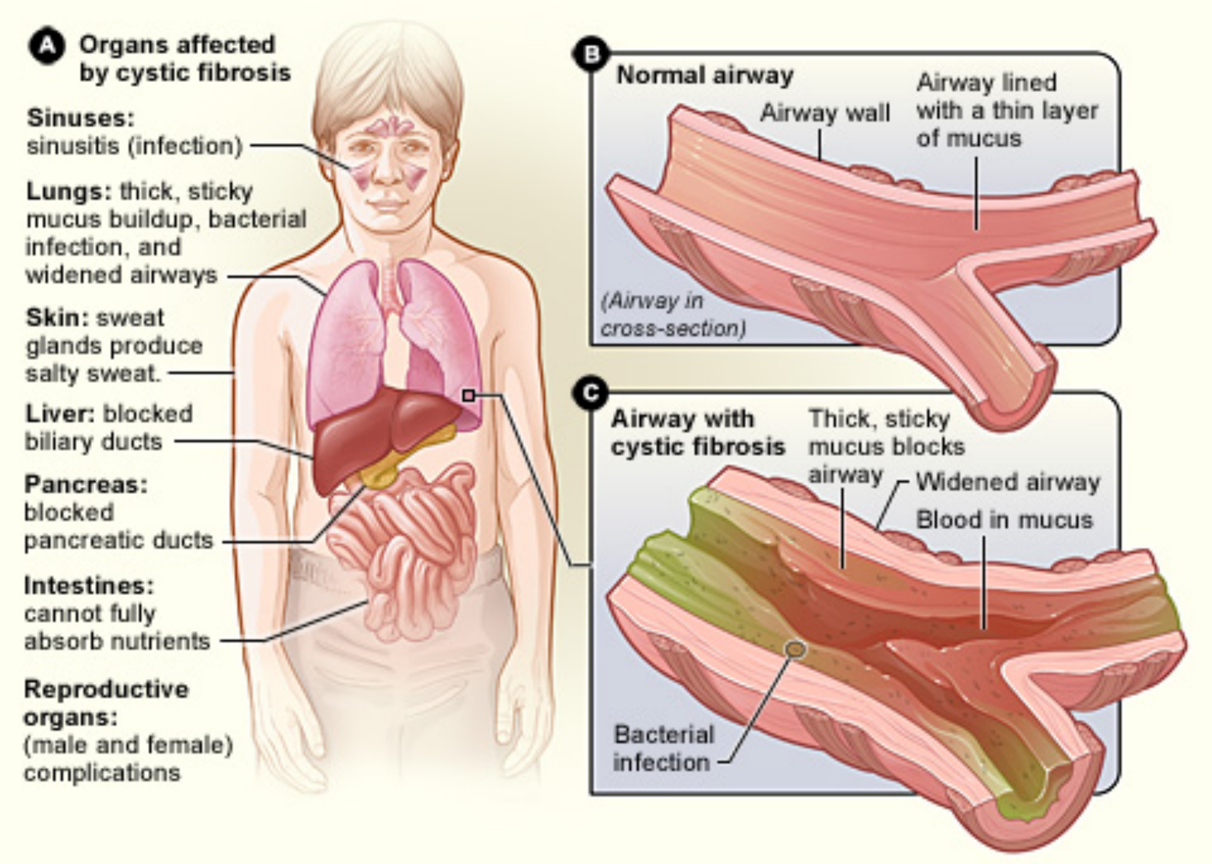


Discuss

- Why are fatal genetic diseases usually recessive?

Human genetic disease examples

- Example recessive disorders:
- •Cystic fibrosis •Tay-Sachs



Human genetic disease examples

- **Codominant disorders example: Sickle-cell Anemia**

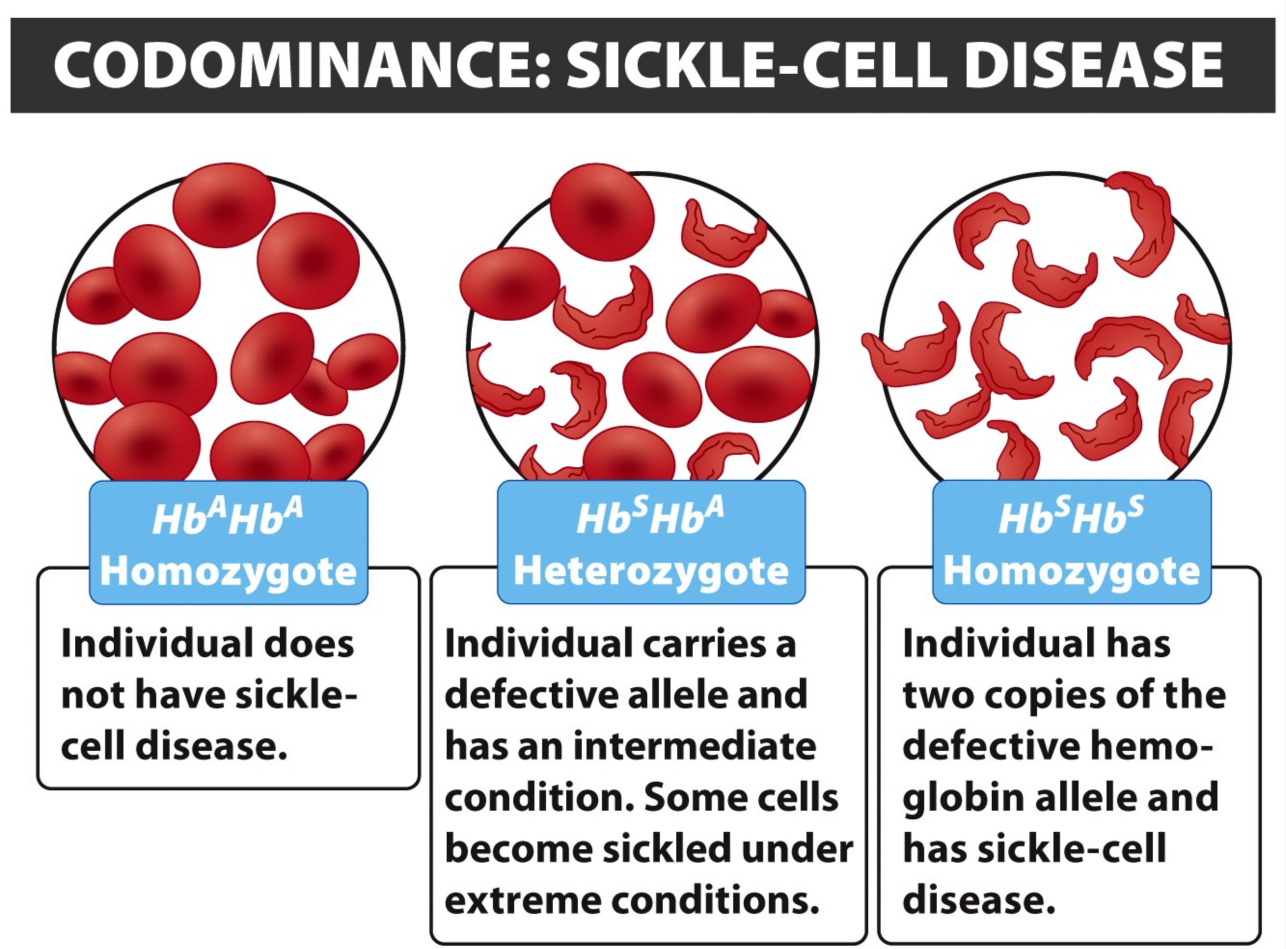


Figure 7-18 part 2
What Is Life? A Guide To Biology
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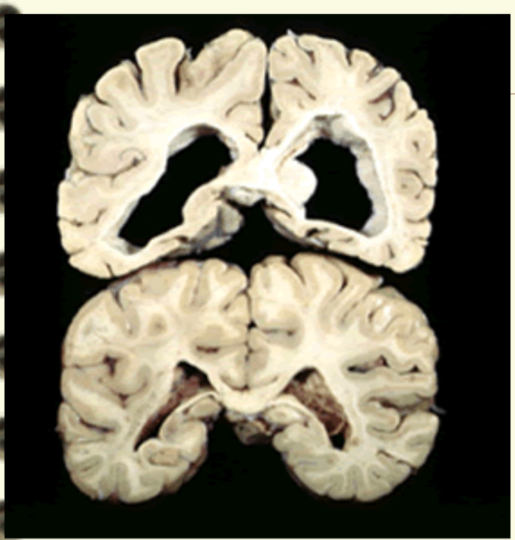
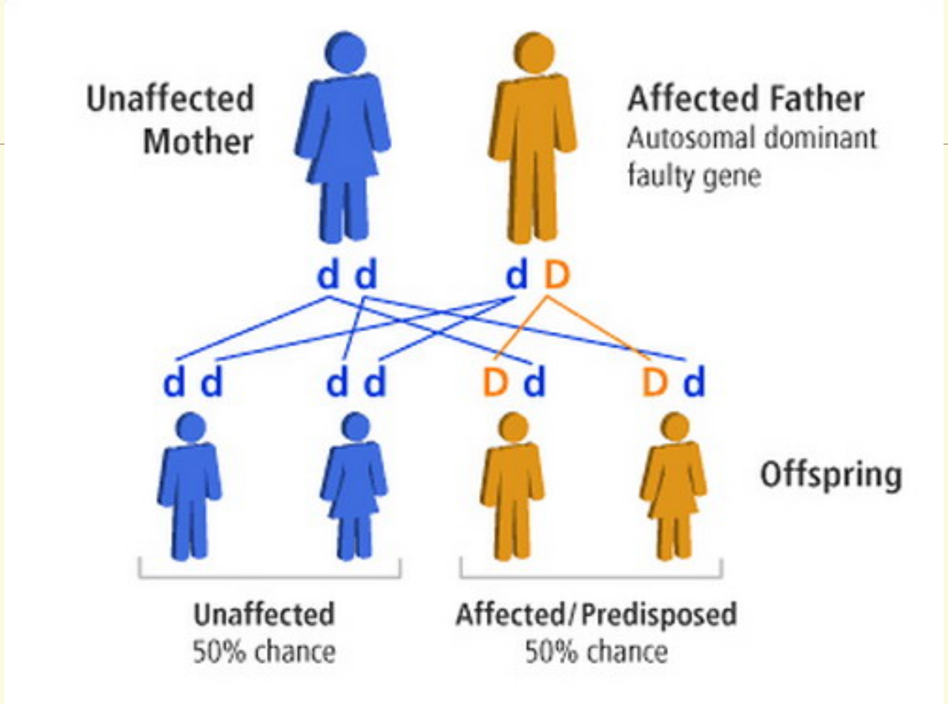
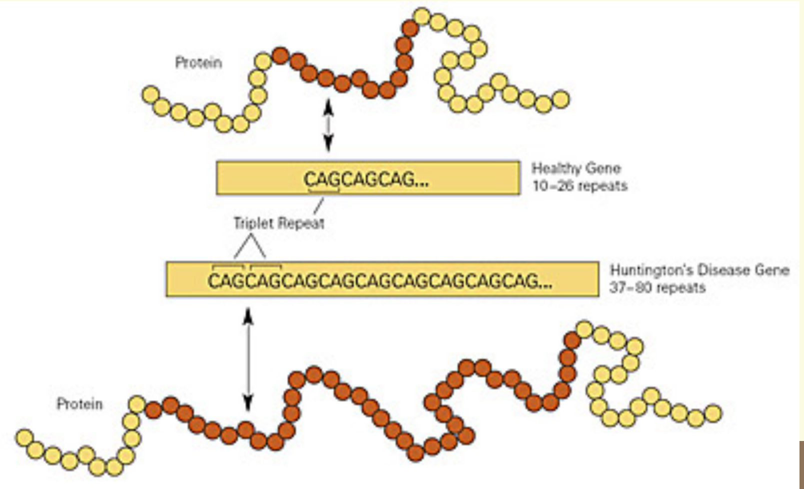
Dominant disorder example: Huntington's disease



The human brain, showing the impact of HD on brain structure in the basal ganglia region of a person with HD (top) and a normal brain (bottom).

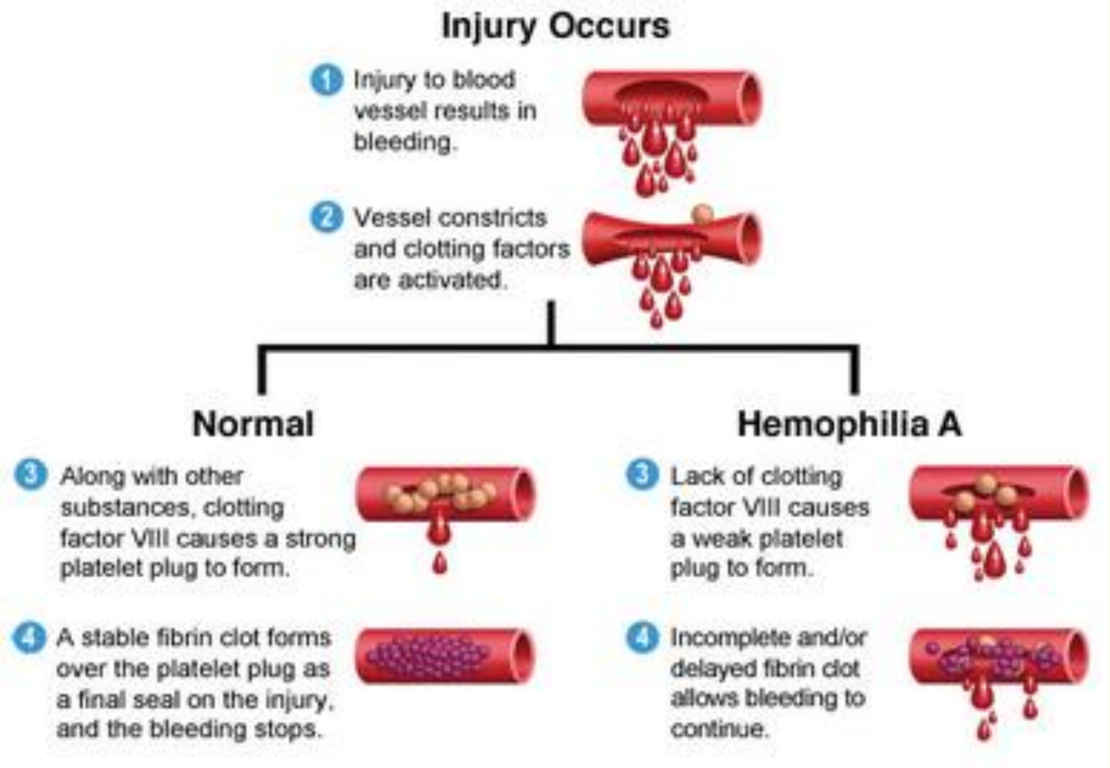
http://kobiljak.msu.edu





Human genetic disease examples

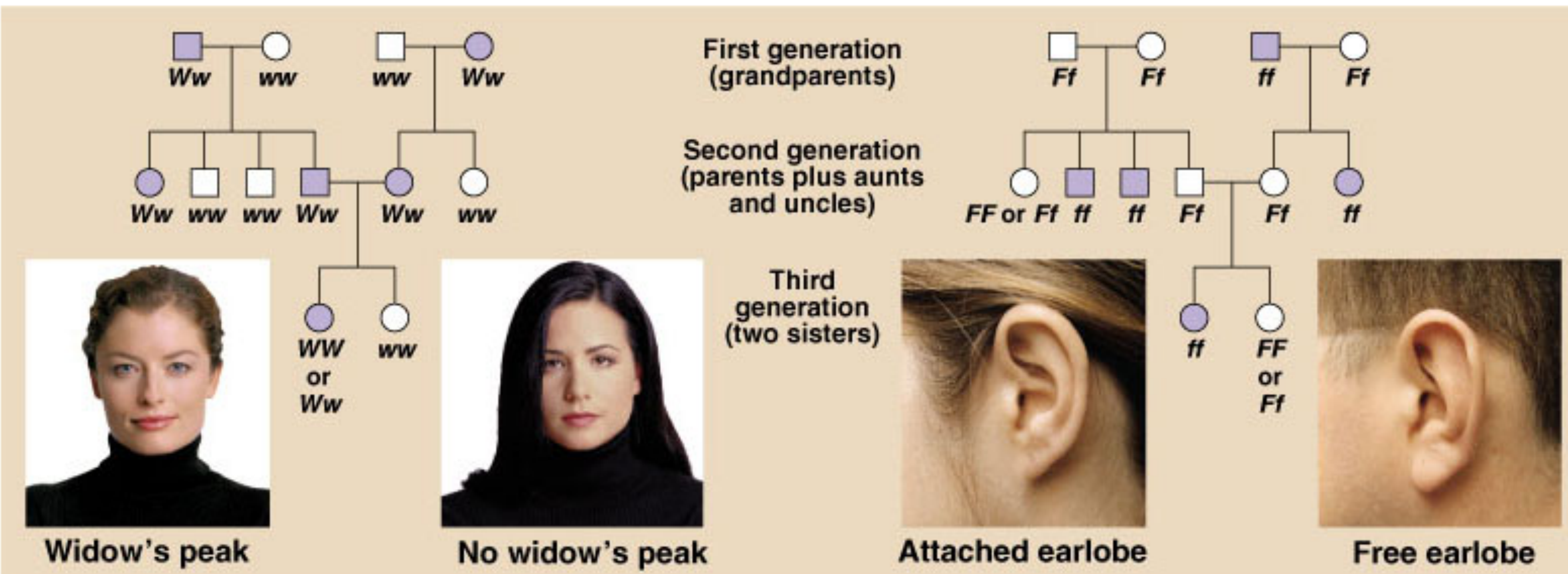
- **Sex-linked:**
  - **Red-green Color-blindness**
  - **hemophilia**



- Radiation and mutagenic chemicals increase the mutation rate and can cause genetic diseases and cancer.
- Application: Consequences of radiation after nuclear bombing of Hiroshima and accident at Chernobyl.
- https://www.youtube.com/watch?v=bPs2GSgeV6I about 4 min video on Chernobyl effects.

Pedigree Analysis

- Skill: Analysis of pedigree charts to deduce the pattern of inheritance of genetic diseases.
- **Square= Male, Circle = Female**
- **Shaded= has the trait (the phenotype)**



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- Skill: Comparison of predicted and actual outcomes of genetic crosses using real data.

- Assignment: P. 176-177 Data-based questions: Analysing Genetic Crosses
  - Input your answers here: https://docs.google.com/forms/d/1A9RIJt23HF55erKByg_KGQsk26-Ya4ZmBz1TvGzjbok/viewform?usp=send_form

Character	F_1 Traits	F_1 Results	F_2 Results (Dom/Rec)		F_2 Ratio
Seeds	Round (R) x Wrinkled (r)	all Round	5474	1850	2.96 : 1
	Yellow (Y) x Green (y)	all Yellow	6022	2001	3.01 : 1
Pods	Axial (A) x Terminal (a)	all Axial	651	207	3.14 : 1
	Full (F) x Constricted (f)	all Full	882	299	2.95 : 1
	Green (G) x Yellow (g)	all Green	428	152	2.82 : 1
Flowers	Violet (P) x White (p)	all Violet	705	224	3.15 : 1
Stem	Tall (T) x Dwarf (t)	all Tall	787	277	2.84 : 1