Grade 11 Biology

Genetic Processes

Class 4

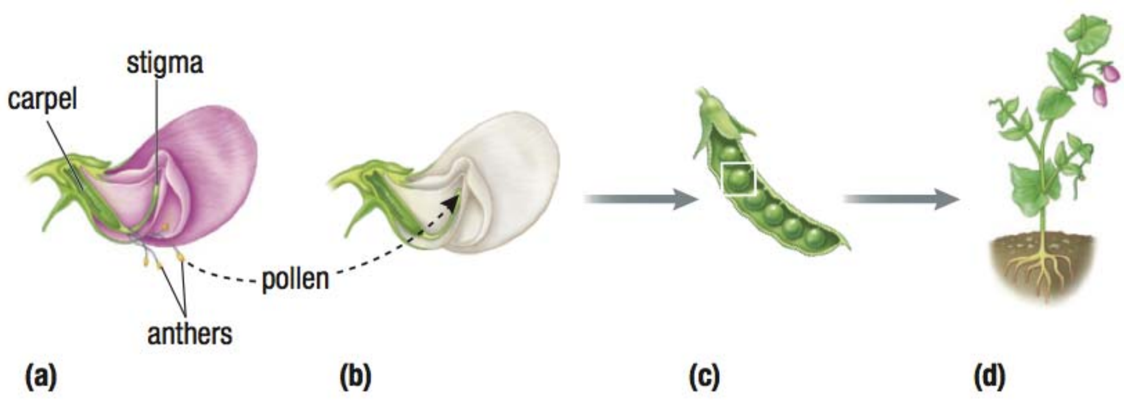
Mendelian Inheritance

Figure 1 Gregor Johann Mendel (1822–1884) is known as the "father of genetics."

- **Trait** – a particular version of a characteristic that is inherited such as eye colour and blood type
- Gregor Johann Mendel conducted experiments by crossbreeding pea plants and recording the offsprings' traits

Mendel's Pea Plants

- *Pisum sativum* – garden pea plant that can self-fertilize and cross-fertilize
- **True Breeding Plants** – an organisms that produces offspring with the same traits when self-pollinated or cross-pollinated with another true-breeding organism with the same trait
- **Hybrid** – offspring of two different true-breeding plants



- Pea plant has several observable characteristics
  - Ex: Smooth or wrinkled pea
  - Ex: Yellow or green seeds

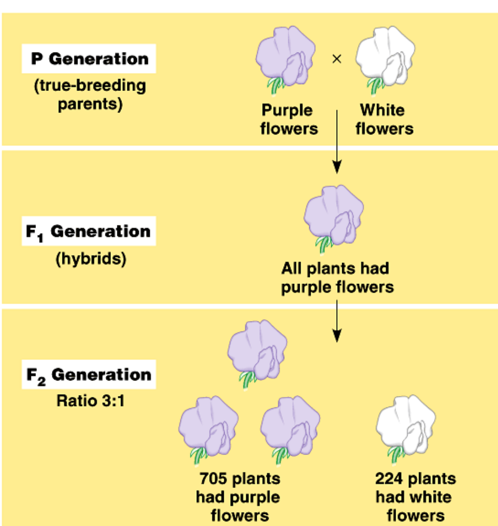
Characteristics of Pea Plants

Table 1 Characteristics and Traits of Pea Plants

Characteristic	Traits
flower colour	purple/white
flower position	axial (along stems)/terminal (at tips)
stem length	tall/dwarf
seed shape	smooth/wrinkled
seed colour	yellow/green
pod shape	inflated/ constricted
pod colour	green/yellow

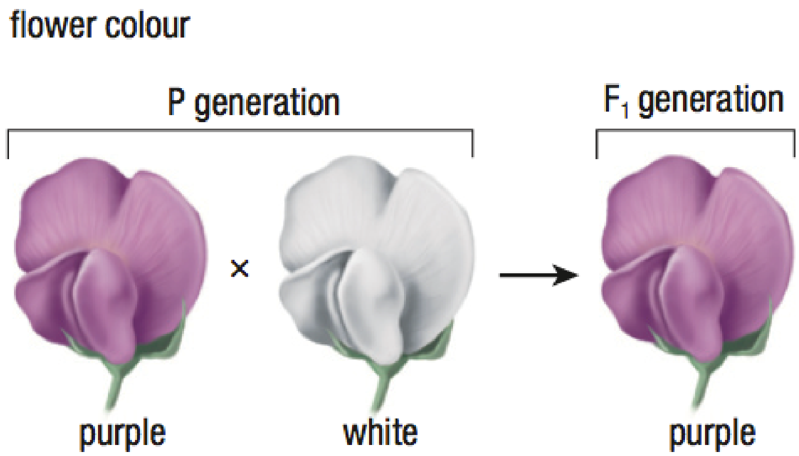
- Mendel performed experiment on 7 hereditary characteristics of the pea plant

Mendel's Experiments

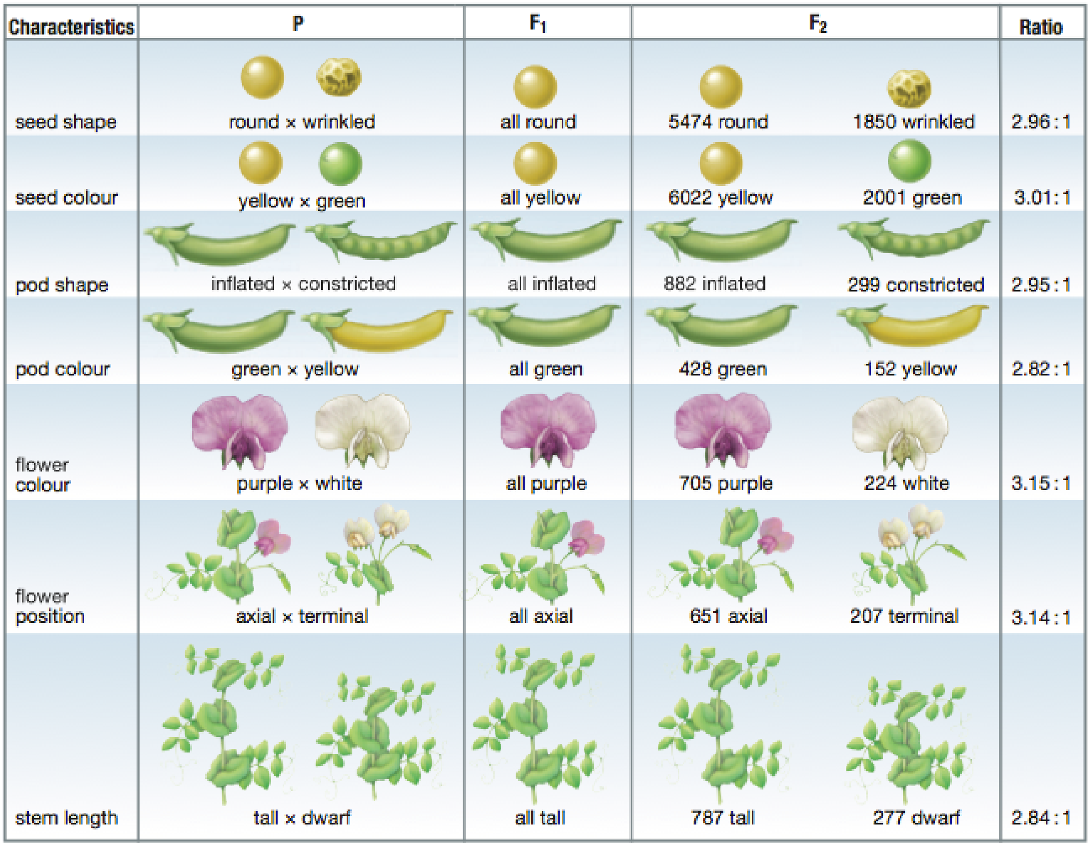


- **Cross** – the successful mating of two organisms from distinct genetic lines
- **P generation** – the parent plants used in a cross
- **F_1 generation** – the offspring of a P-generation cross
- **F_2 generation** – the offspring of a F_1 generation cross

- F_1 generation differed from each other in only one characteristic making them **monohybrids**
- This type of cross is called a **monohybrid cross**



- Mendel observed that when F_1 generation plants were self-pollinated, F_2 generation had purple and white flowers
- White flower trait did not disappear but was masked
- Mendel recorded the numbers of the F_2 generation plants according to their traits and found a pattern
- Ratio of F_2 generation were repeatedly 3:1



Characteristics	P	F$_1$	F$_2$		Ratio
seed shape	round × wrinkled	all round	5474 round	1850 wrinkled	2.96 : 1
seed colour	yellow × green	all yellow	6022 yellow	2001 green	3.01 : 1
pod shape	inflated × constricted	all inflated	882 inflated	299 constricted	2.95 : 1
pod colour	green × yellow	all green	428 green	152 yellow	2.82 : 1
flower colour	purple × white	all purple	705 purple	224 white	3.15 : 1
flower position	axial × terminal	all axial	651 axial	207 terminal	3.14 : 1
stem length	tall × dwarf	all tall	787 tall	277 dwarf	2.84 : 1

First Law of Mendelian Inheritance

- Traits are passed on by discrete heredity units which Mendel called factors
- Factor that appears is called the **dominant factor**
- Factor that is hidden is called the **recessive factor**

Law of Segregation

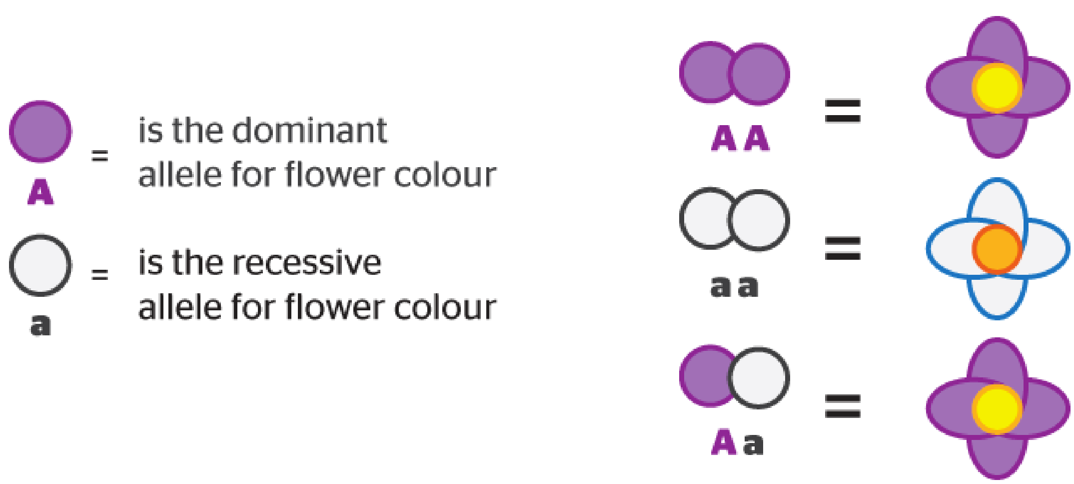
- An organism carries two factors (alleles) for each characteristic, one from each parent
- Parent organisms donate only one copy of each gene in their gametes
- During meiosis the two copies of each gene separate (segregate)

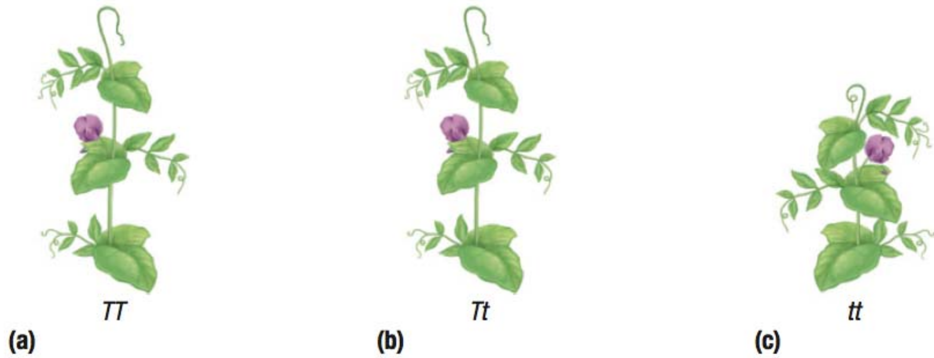
Alleles

- Each gene has a locus or position on a chromosome
- Most genes exist in at least two forms and each form is called an allele
- Different allele combinations results in different traits
  - **Homozygous** – two alleles for the trait are the same
  - **Heterozygous** – two different alleles for the trait

- **Genotype** – the genetic makeup of an individual
- **Phenotype** – the individual's outward appearance with respect to a specific characteristic
- **Dominant Allele** – allele that expresses its phenotypic effect
- **Recessive Allele** – allele that is hidden when associated with a dominant allele; expressed only with both alleles are recessive

- Geneticists use letters to represent alleles
- Upper-case represents dominant alleles
- Lower-case represents recessive alleles





T = dominant allele for tall trait
t = recessive allele for short trait

	(a)	(b)	(c)
Genotype	*T T*	*T t*	*t t*
Phenotype	Tall	Tall	Short
Combination	Homozygous	Heterozygous	Homozygous

Influence of Alleles on Phenotype

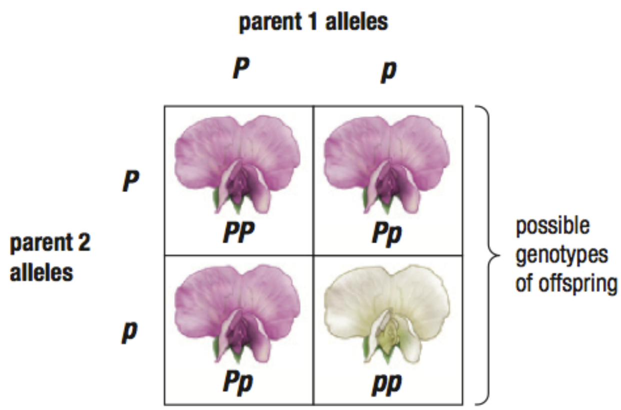
What makes an allele dominant or recessive?

- Dominant allele may code for a working protein
  - Ex: Melanin is a pigment and humans have two forms of the gene melanin
  - *M* = produces melanin
  - *m* = does not produce melanin
- *mm* individuals have albinism

Figure 6 People with albinism lack melanin and are extremely susceptible to sun damage.

Punnett Squares

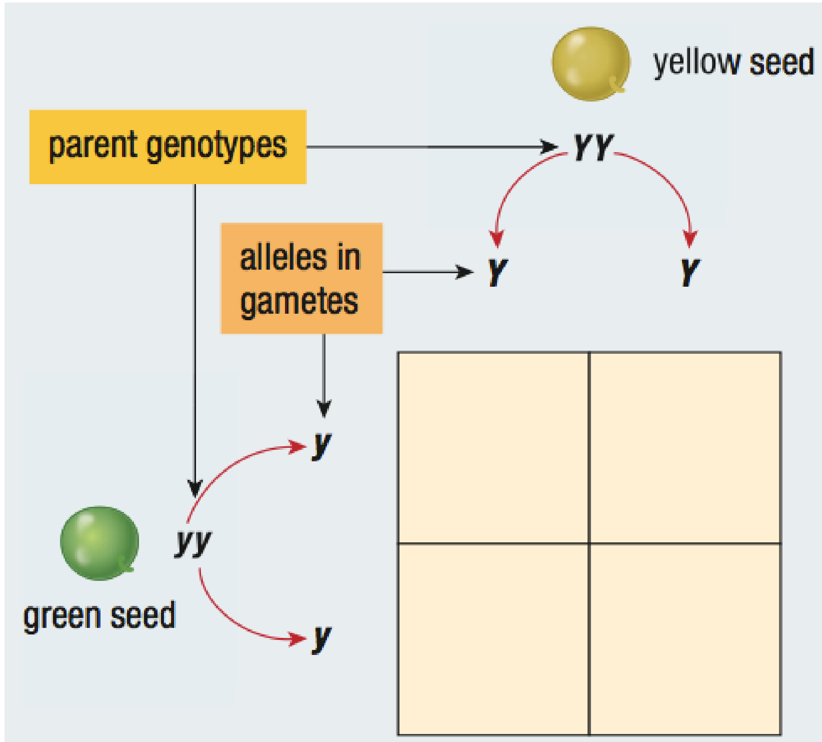
- A diagrams used to predict the proportions of genotypes in the offspring resulting from a cross between two individuals



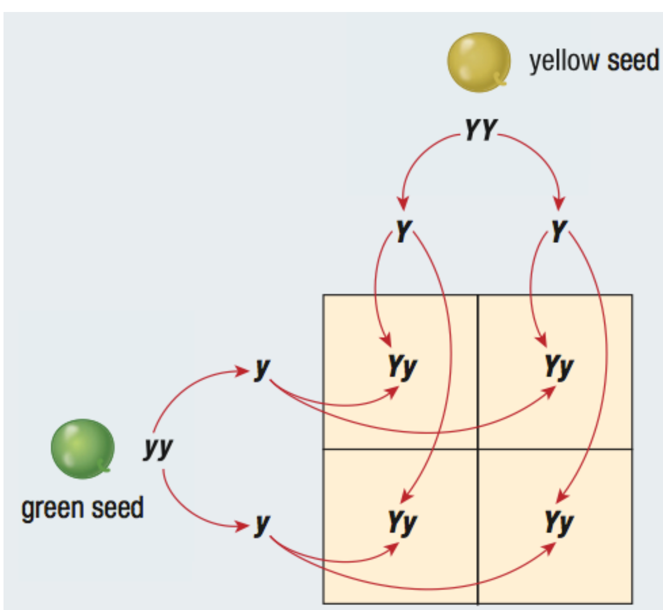
Steps to Draw Punnett Squares

Consider a cross between a pea plant that is homozygous for yellow seeds (*YY*) and a plant that is homozygous for green seeds (*yy*).

1) Draw a Punnett Square
2) Write the alleles of Parent 1 on the top
3) Write the alleles of Parent 2 on the left side



3) Fill in the boxes by combining the alleles corresponding to each row and column



F_1 Generation

Genotype: *Yy*

Phenotype: Yellow

Checkpoint

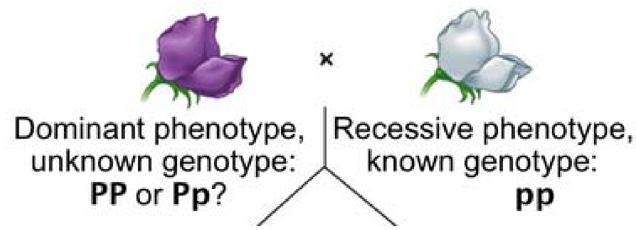
Two F_1 heterozygous yellow seed plants (*Yy*) are crossed. Determine the genotype and phenotype of the F_2 generation.

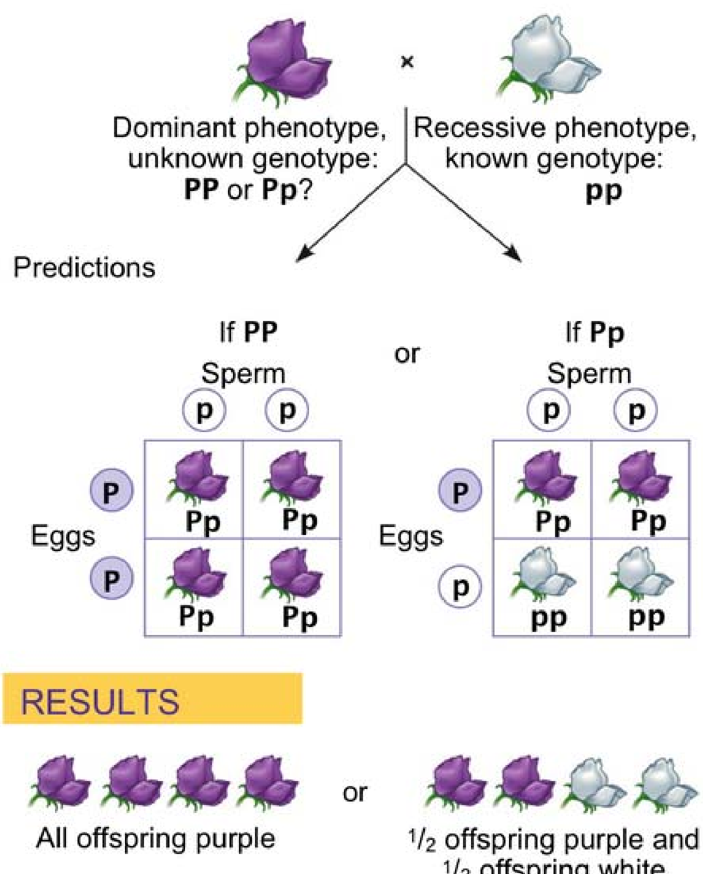
Checkpoint

In one cross of tomato plants, 1821 red tomato plants and 615 yellow tomato plants were produced. Determine the probable genotype of the parents. Which allele is dominant? Use the letter *R* and *r* to represent the alleles.

Test Cross

- Test cross determines if an individual exhibiting a dominant trait is homozygous or heterozygous
- Always performed between the unknown genotype and a homozygous recessive genotype





Checkpoint

Sample Problem 1: Performing a Test Cross

Animal and plant breeders are often interested in whether or not an individual will consistently produce offspring with a desired trait. A breed of rooster has a dominant trait (*S*)—a comb that resembles a series of fingers—while a breed with a recessive trait (*s*) has a flat comb (**Figure 12**).

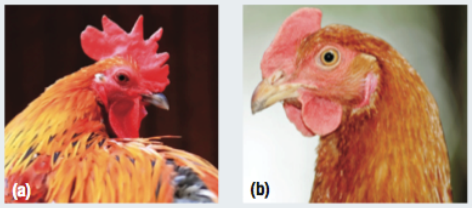


Figure 12 A rooster could have (a) a five-fingered comb or (b) a flat comb

A breeder would like to use a true-breeding, homozygous, five-fingered-comb rooster as a stud in her breeding program. She has many roosters to choose from but does not know if they are heterozygous (*Ss*) or homozygous dominant (*SS*) for the trait.

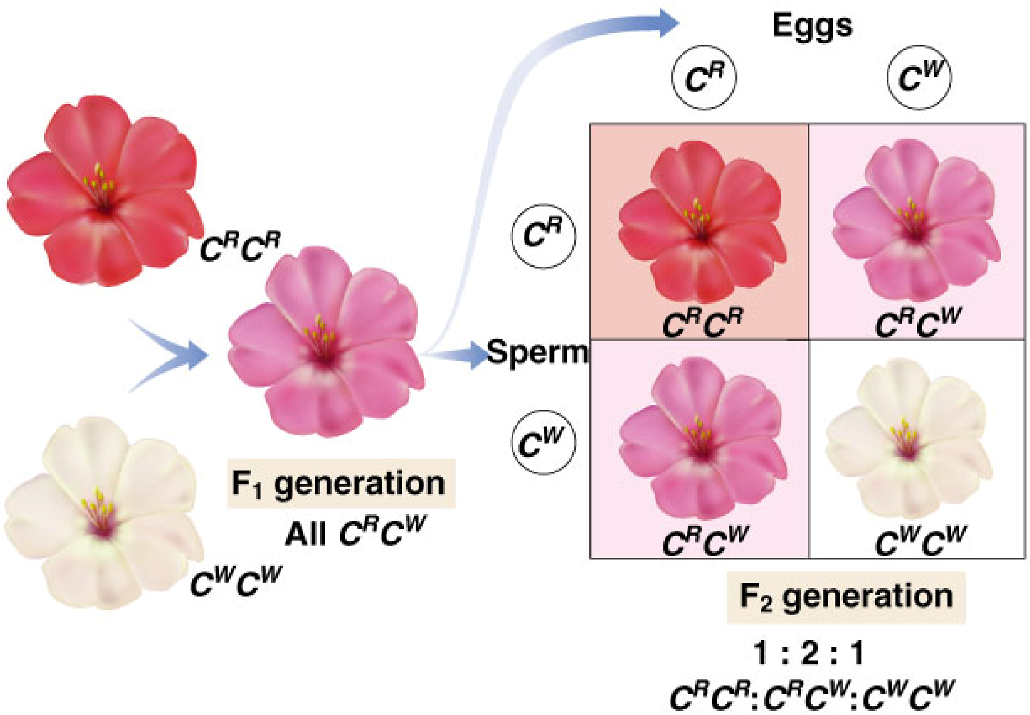
(a) What type of hen should she cross with the roosters to determine whether a particular rooster is homozygous or heterozygous for the five-fingered comb? Explain your reasoning using Punnett squares.

(b) What are the expected results?

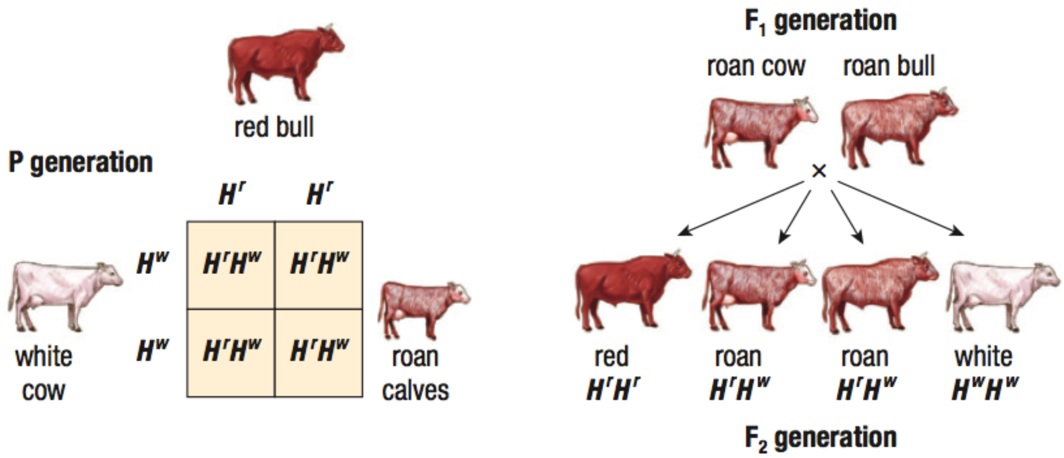
Variations in Heredity

- **Complete dominance** – only one allele is expressed despite the presence of the other allele
- Not all traits exhibit complete dominance
- Variations in the patterns of heredity exist and dominance is not always complete

- **Incomplete Dominance** – Neither allele dominates the other and both have an influence on the individual resulting in partial expression
- Snapdragon plant
  - C^R is the allele for red; C^W is the allele for white

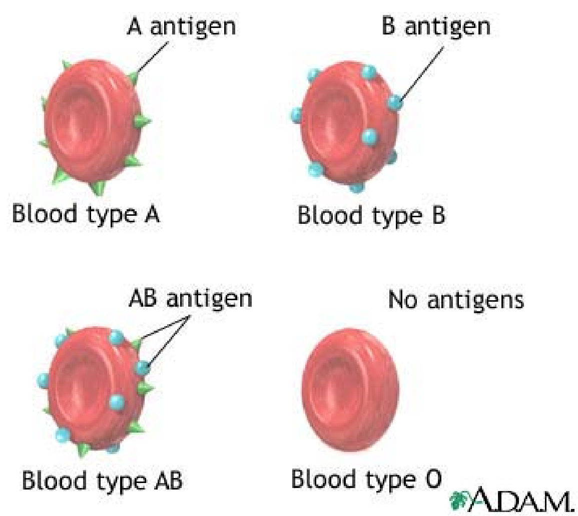


- **Codominance** – both alleles are expressed fully to produce offspring with a third phenotype



Blood Types

- Red blood cells have special markers called antigens on their membranes



- Blood type gene has three possible alleles: I^A, I^B and I
- Type AB is an example of codominance
- Type O lacks the antigens A and B

Table 1 The Distribution and Expression of the Blood Type Alleles

Genotype	Blood type	Able to receive blood from
I^AI^A	A	A, 0
I^Ai	A	A, 0
I^BI^B	B	B, 0
I^Bi	B	B, 0
I^AI^B	AB	A, B, AB, 0
ii	0	0

Checkpoint

A newborn baby has type O blood. The mother has type A blood and the father has type AB blood. Is this possible?

Blood Transfusions

- Type A blood produces an immune response against Type B blood and AB blood because they recognize the B antigen as foreign
- Type B blood produces an immune response against Type A blood and AB blood because they recognize the A antigen as foreign

- Type AB can take all types of blood since it recognizes antigen A and B (universal acceptor)
- Type O can only take Type O blood (universal donor)
- If incompatible blood is transfused, antibodies will attack the foreign antigens which causes clumping of the blood cells
- Clumping can block capillaries and prevent oxygen delivery leading to death