Chapter 12

Mendel and the Gene Idea

Mendel and The Gene Idea

- Gregor Mendel was a monk who experimented with pea plants and was also a scientist
- He is known as the "Father of Genetics."
- Mendel's two fundamental principles of heredity are now known as the *law of segregation* and the *law of independent assortment*.

Traits of the Pea Plants

- Plant height
- Flower position on stem
- Pod color
- Pod appearance
- Seed texture
- Seed color
- Flower color

Controlled Experiment

- Mendel took all the stamen off one plant and then moved the pollen himself from one plant to the other
- Self-pollination = allowing plants to mate without interference
- Cross-pollination = manually moving the pollen from one plant to the next

Experiment

- Mating of 2 true-breeding varieties – self pollination

P generation (parental) – cross pollination

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F_1 generation (1st filial) – self pollination

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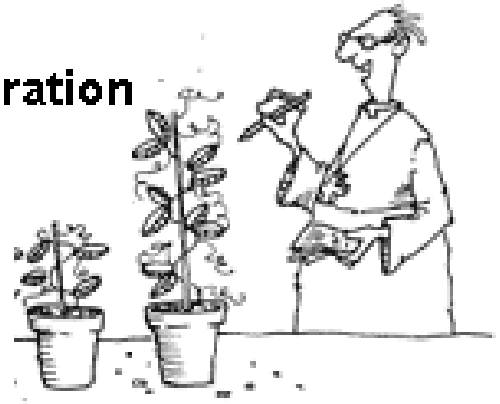
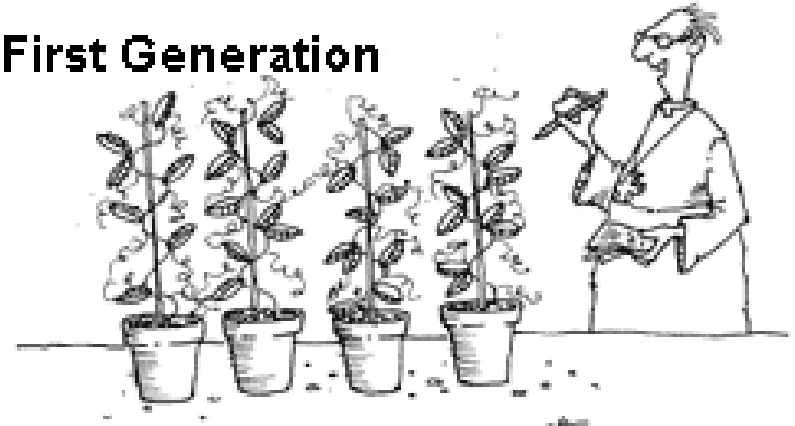
F_2 generation (2nd filial)

Visualizing Mendel's Experements

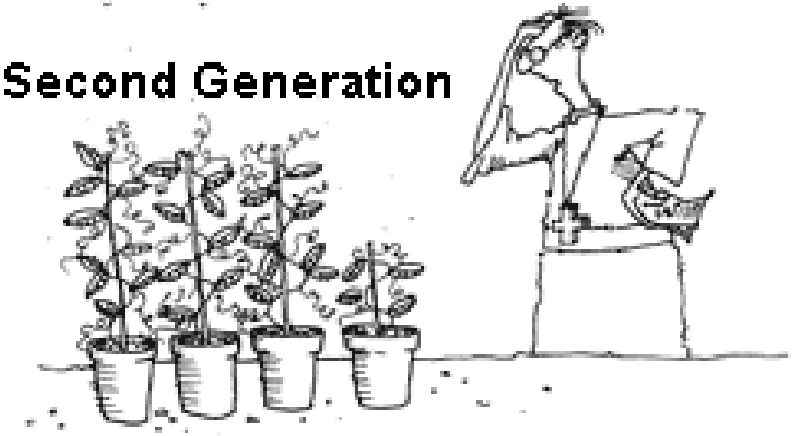
Parent Generation



First Generation



Second Generation



Review Question

- Mendel carefully removed the anther from one flower and placed the pollen on the pistil of another flower. What is this type of pollination called?

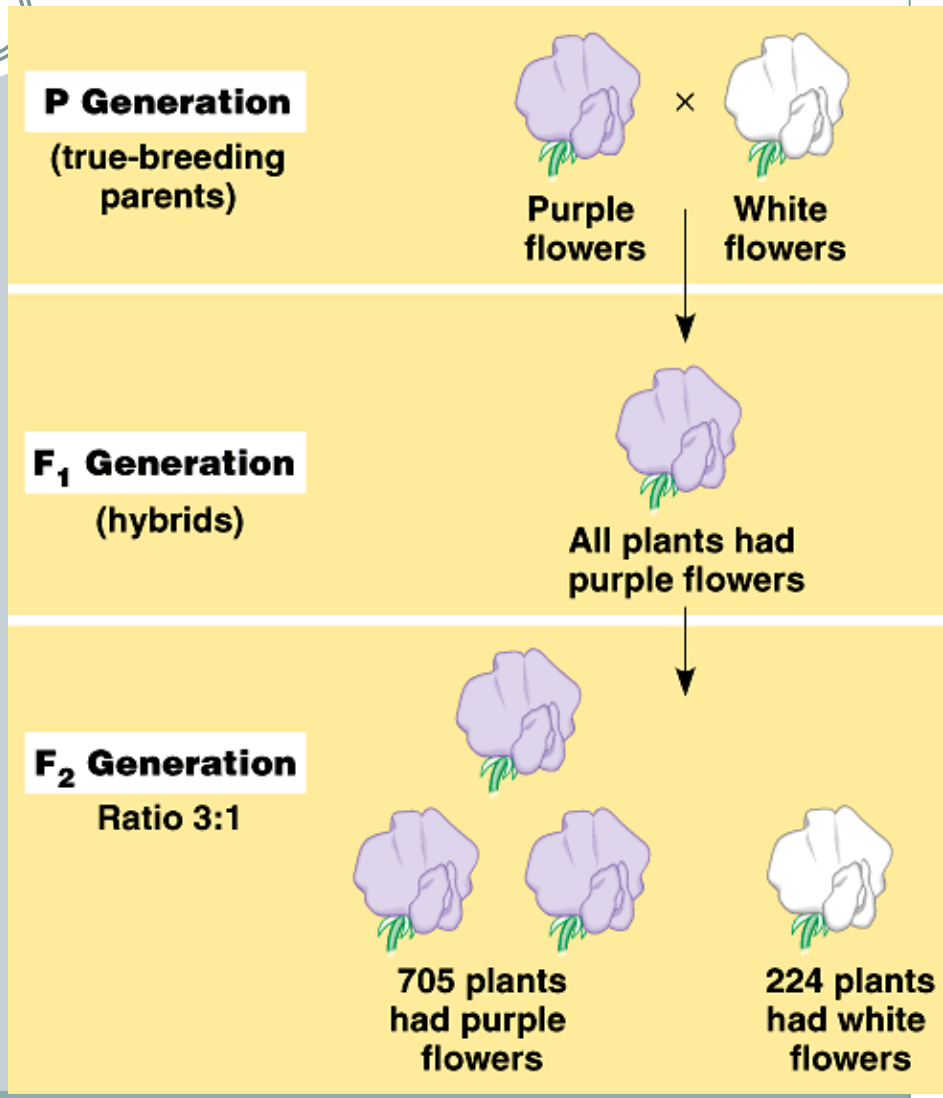
A. Self-pollination
B. Cross-pollination
C. True-pollination

Some Useful Genetic Vocabulary

- *Dominant* – masks or dominates another factor (trait)
- *Recessive* – gets masked or dominated by another factor (trait)

- Mendel called the different varieties of traits factors
- Scientist now refer to them as *alleles*

- *Alleles* – different versions of a gene
  - accounts for variations in inherited characters



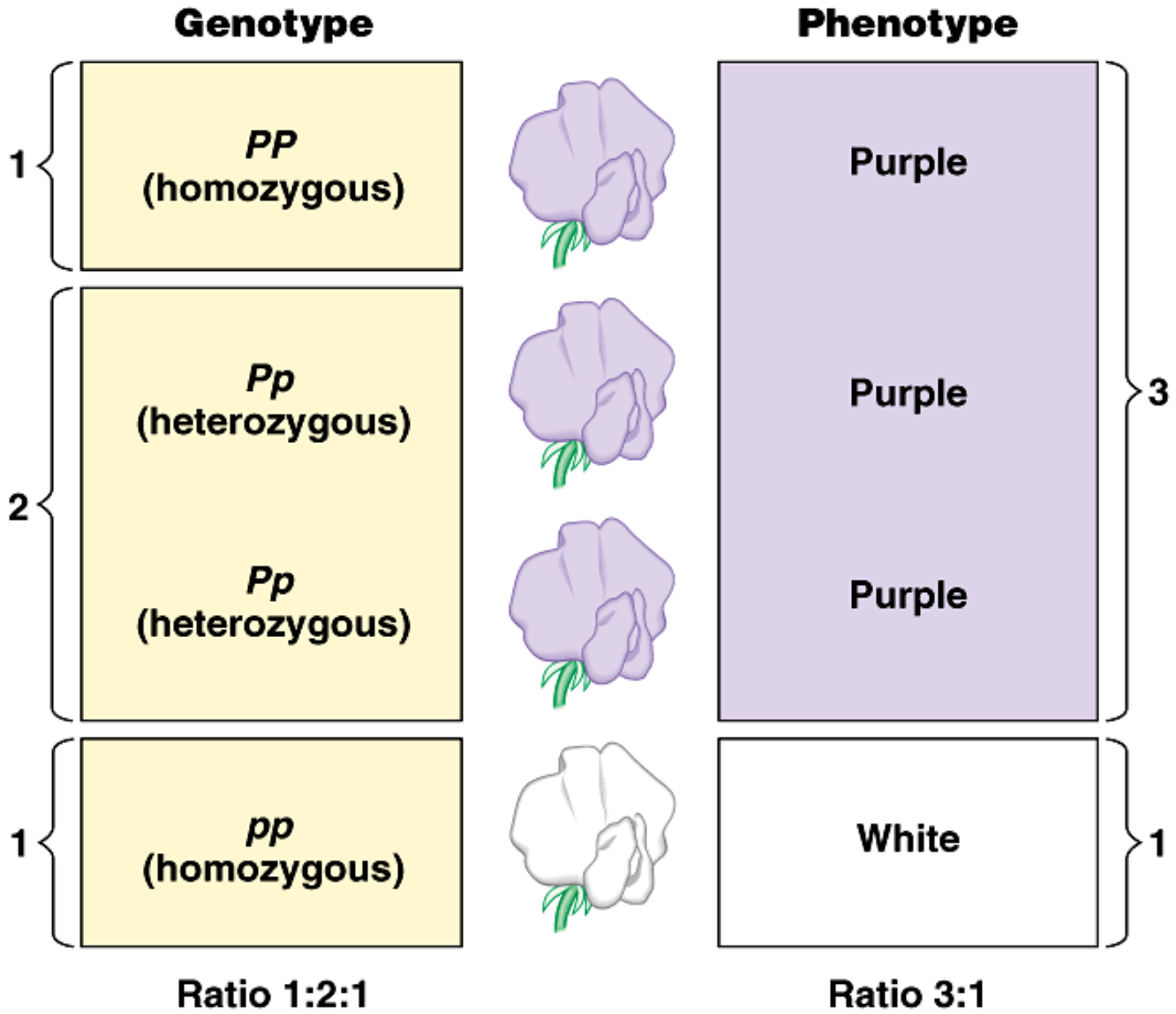
Some Useful Genetic Vocabulary

- *Homozygous* – an organism having a pair of identical alleles for a gene (PP or pp)
- *Heterozygous* – an organism having two different alleles for a gene (Pp)
- *Phenotype* – an organism's traits or physical appearance (purple or white flowers)
- *Genotype* – an organism's genetic makeup (PP, pp, or Pp)

Mendel's Conclusion

- Something within the plant controlled the characteristics
- Determined that "factors" were inherited from the parents
- Mendel knew that the white trait did not disappear in the F_1 generation
- Now know there are dominant and recessive traits

Genotype vs. Phenotype



Review Question

- What is the term that describes an organisms combination of genetic material?

A. Dominant
B. Recessive
C. Genotype
D. Phenotype

Review Question

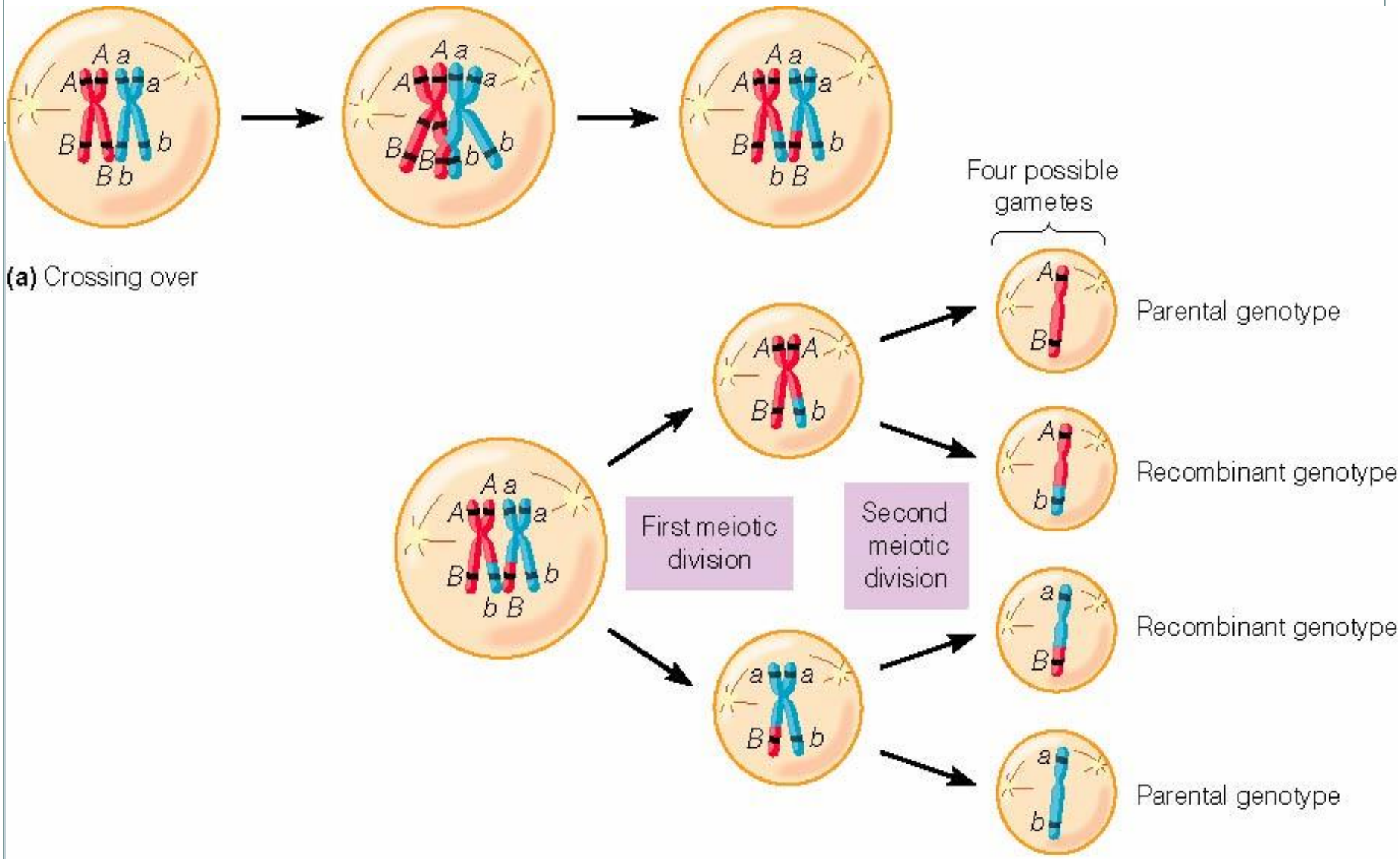
- What term is used to describe the allele that is not expressed when another allele is present?

A. Dominant
B. Recessive
C. Genotype
D. Phenotype

Law of Segregation

- States: During the formation of either the egg and sperm cell (Meiosis), the two alleles for a character (trait) separate

- When the sperm and egg cell come together, an organism will inherit the two alleles - one from each parent


(a) Crossing over
Four possible gametes
Parental genotype
Recombinant genotype
Recombinant genotype
Parental genotype
First meiotic division
Second meiotic division

Law of Independent Assortment

- States: Each pair of alleles during gamete formation line up independently of each other
- In pea plants, flower color is independent of seed color, is independent of seed-shape, etc.

- *Monohybrid* – cross involving one trait
- *Dihybrid* – cross involving two traits

Probability

- Probability = # of times an event is expected to happen / # of opportunities for an event to happen (total)

- Ex: Coin Flip
  - Probability of getting heads = 1 time expected / 2 opportunities
  - Heads = .5 or 50% chance

Punnett Square

- Punnett Square = chart used to predict the probability that certain traits will be inherited in the offspring

- Parent alleles located in egg or sperm cells are placed along the side and top of the square

Cross: Homozygous Dominant and Homozygous Recessive

	b	b
B		
B		

Answers:

Test Cross

- Test cross is used to determine if an organism that shows the dominant phenotype is either homozygous dominant or heterozygous

- Mate a homozygous recessive individual with two different dominant phenotype individuals
  - If the ratios of offspring are all dominant, then the parent is homozygous dominant
  - If the ratios of offspring are 2:2, then the parent is heterozygous

Other Types of Dominance

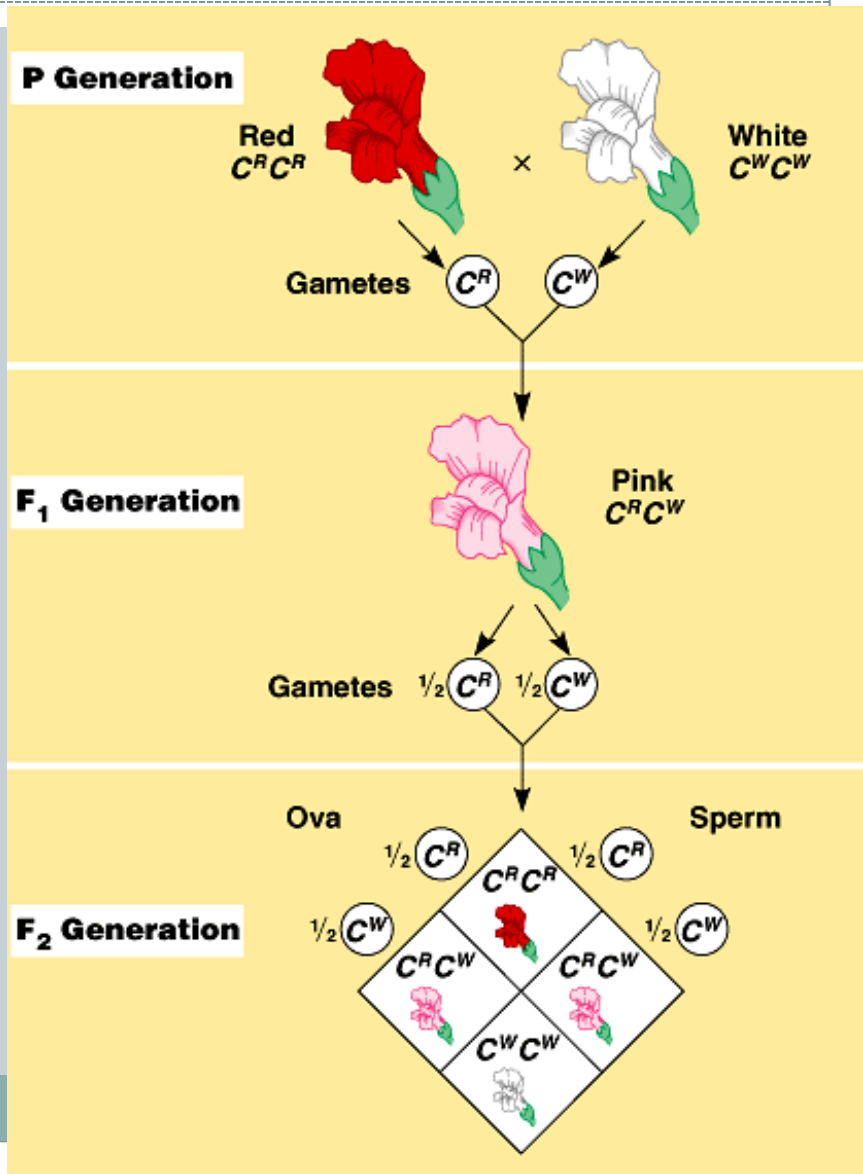
- Complete dominance
- Incomplete dominance
- Co-dominance
- Multiple Alleles
- Sex-linked genes
- Polygenic inheritance

Complete Dominance

- One allele hides the expression of another allele

Incomplete Dominance

- The F_1 hybrids have an appearance somewhere in between the phenotypes of the two parental varieties (blending of traits)
- Example: Snapdragons, 4 o'clock flowers



Co-dominance

- Both alleles for a gene are expressed in the offspring

- Ex: strips on a zebra or spots on a leopard
- Ex: Blue Roan Horse
  - Horse has a mixture of black and white hair, giving the horse a bluish appearance, rather than a gray color.

Multiple Alleles

- Genes that exist in populations in more than two allelic forms

- ABO blood groups in humans
  - Blood types can be A, B, AB, or O
  - The letters refer to two carbohydrates that are found on the surface of red blood cells
  - Blood cells may have one substance or the other (type A or B), both (type AB), or none (type O)

Blood Types

- Type A phenotype = AA or AO genotype
- Type B phenotype = BB or BO genotype
- Type AB phenotype = AB genotype
- Type O phenotype = OO genotype

Blood Type Problem

- Find the genotypic and phenotypic ratios for each of the crosses

Cross AA and AB:	G = 2:2 AA:AB	P = 2:2 A:AB
Cross AO and BO:	G = 1:1:1:1	P = 1:1:1:1
Cross BB and AO:	G = 2:2 AB:BO	P = 2:2 AB:B
Cross OO and AB:	G = 2:2 AO:BO	P = 2:2 A:B

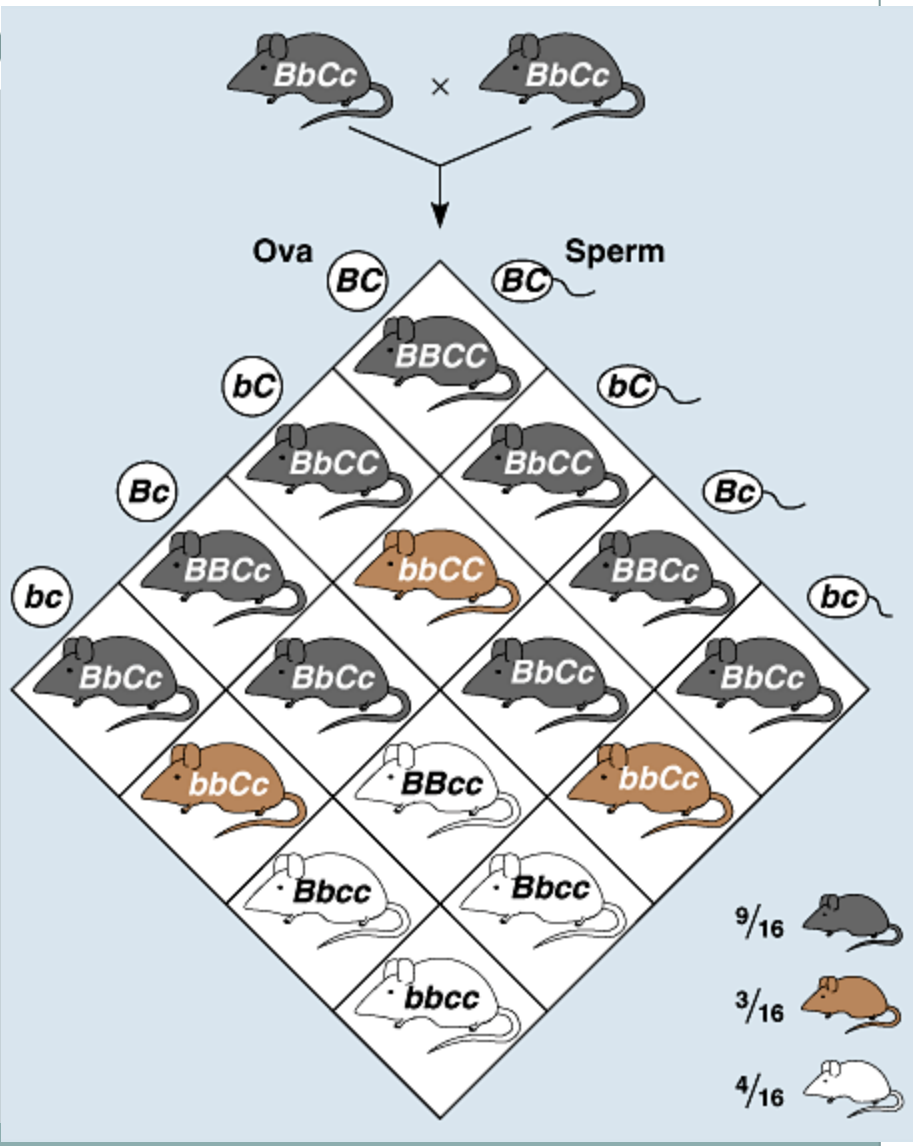
Sex-linked or Linked Genes

- Sex-linked = genes on the X or Y chromosome
  - Ex: colorblindness, male patterned baldness, hemophilia

- Linked genes = genes are so close together on a chromosome that will cross over together during Meiosis

Epistasis

- A gene at one location on the DNA alters the phenotypic expression of a gene at a second location.
- In mice – *B* = black fur, *b* = brown fur
- *C* is a dominant allele that determines if pigment is deposited in the hair. If a mouse inherits *cc*, it will be albino.

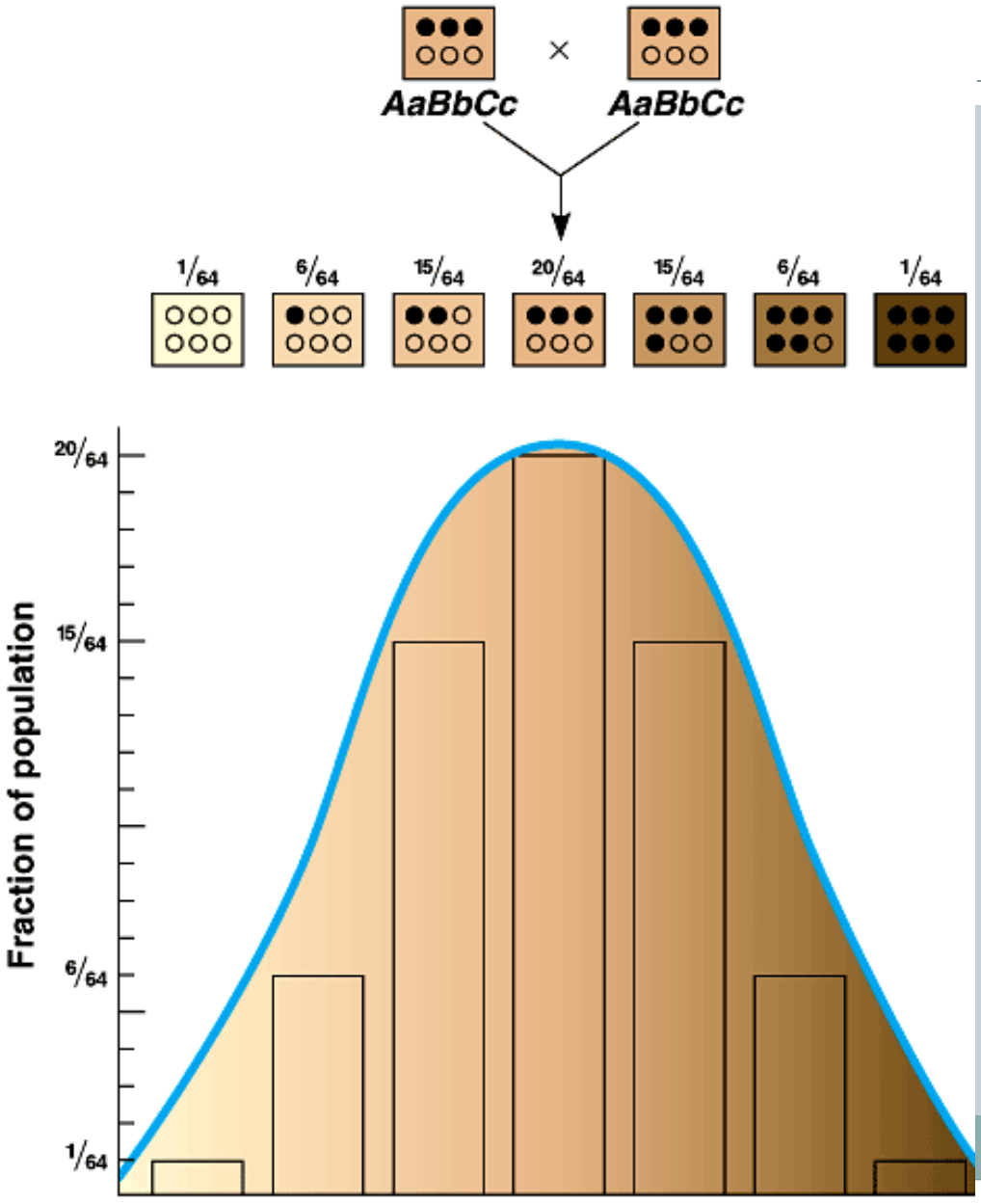


Polygenic Inheritance

- Two or more genes influence the expression of a single phenotypic character.
- Varies in a population along a continuum.

- Ex: eye color, human skin color and height
  - Human skin color has at least 3 separately inherited genes

Polygenic Inheritance



Hardy-Weinberg Equilibrium

- When the alleles in a population are not changing over generations, then the population is in genetic equilibrium
  - If the alleles are changing, then the population is said to be evolving
- Dominant allele = p variable
- Recessive allele = q variable
- Equation: $p + q = 1$
  - The percentage of dominant alleles (in decimal form) + percentage of recessive alleles (in decimal form) = 100%

Hardy-Weinberg Equilibrium

- You can measure the amount of homozygous dominant, heterozygous, and homozygous recessive individuals in a population

- Equation: $p^2 + 2pq + q^2 = 1$
  - All percentages are listed in decimal form and the total will be equal to 100% or 1

Conditions for Hardy-Weinberg Equilibrium

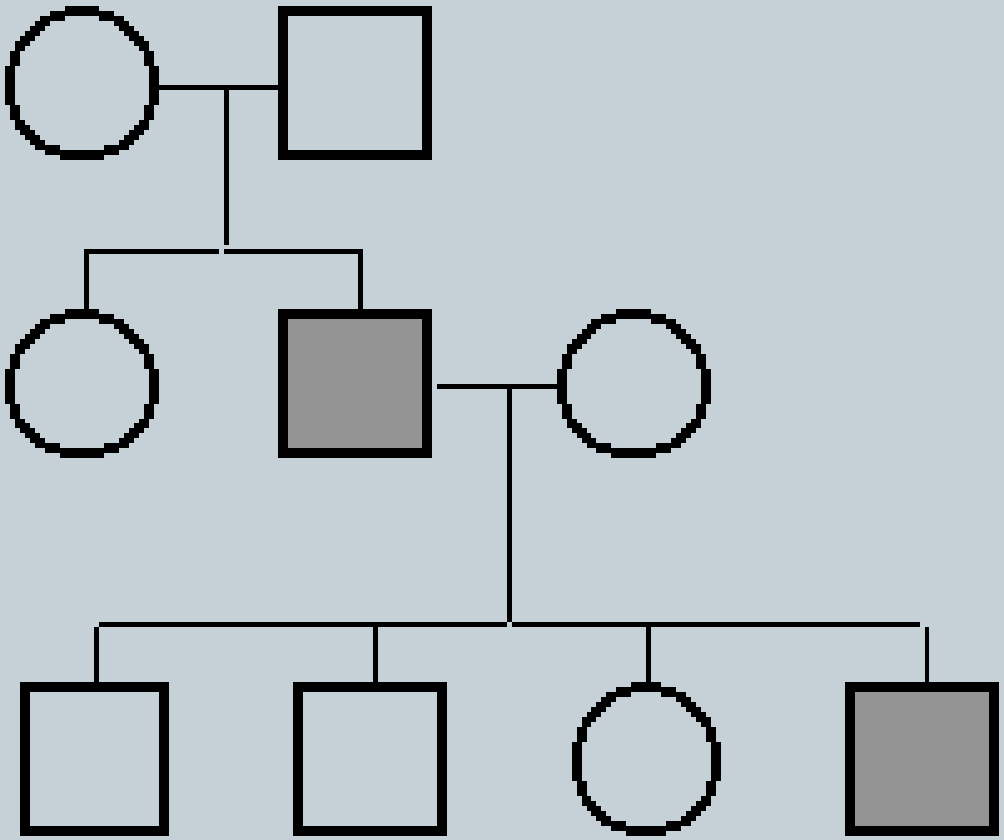
- Large population
- No mutations
- Random mating
- No natural selection
- No migration in or out of a population

- If all these conditions are met, then the population's allele frequencies (amount of each allele) will not change and will not be evolving

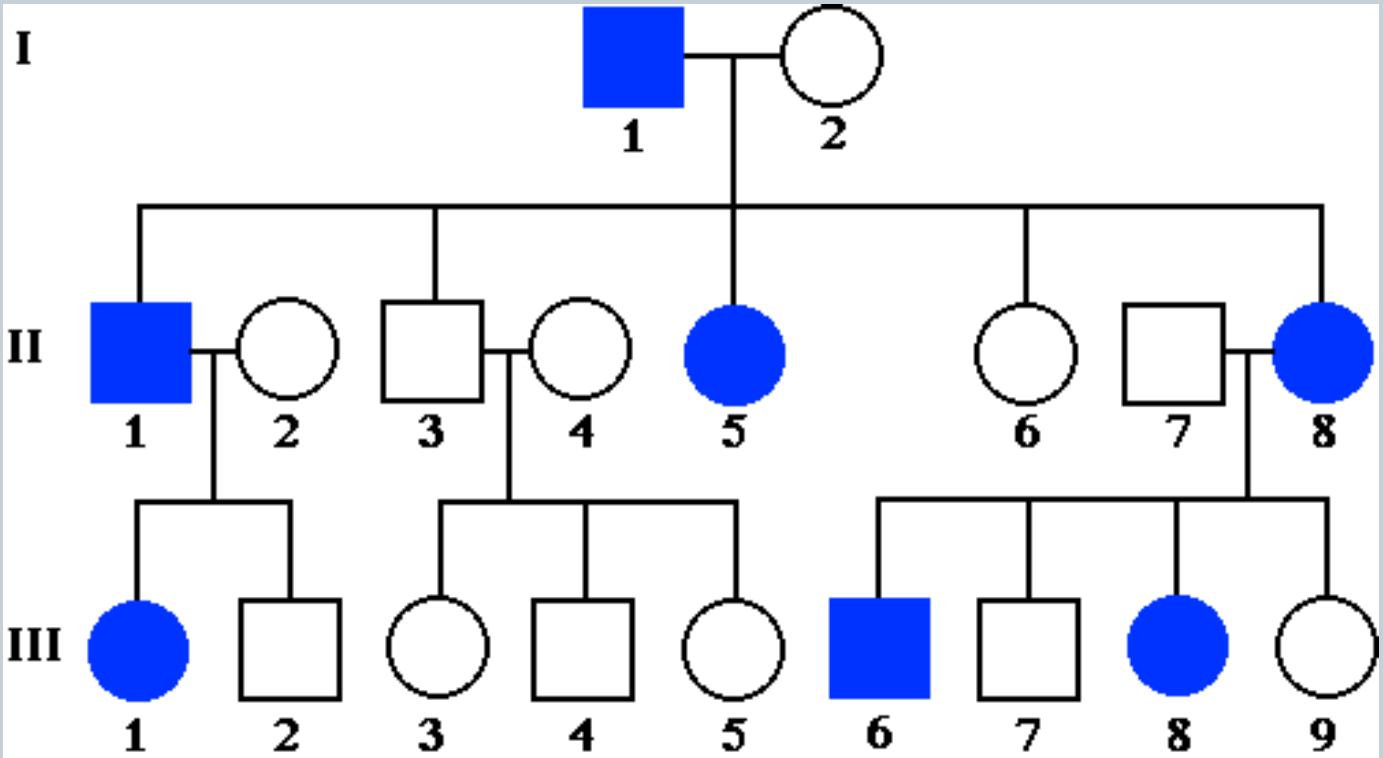
Pedigree Analysis

- A family history that shows how a trait is inherited over several generations
  - Circle = female
  - Square = male
  - Shaded = has the trait

Pedigree Analysis



Pedigree Analysis



Pedigree 1. An idealized pedigree of a family with hypercholesterolemia, an autosomal dominant disease where the heterozygote has a reduced number of functional low density lipoprotein receptors.

Genetic Disorders

- Sickle cell anemia
  - Autosomal recessive
  - Poor blood circulation and decreased ability of your blood to hold oxygen
- Cystic fibrosis
  - Autosomal recessive
  - Mucus buildup in the lungs making breathing difficult; short lifespan

Genetic Disorders

- Hemophilia
  - Sex-linked recessive
  - Failure of blood to clot
- Huntington disease
  - Autosomal dominant
  - Gradual deterioration of the brain