Mendelism Deviations

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Extensions of Mendelian Genetics

1. Co-dominance
2. Incomplete Dominance
3. Multiple alleles
4. Lethal alleles
5. Epistasis
6. Polygenic Inheritance
7. Linked Genes
8. Crossover values and Gene Mapping
9. Sex Linked Genes

INTRODUCTION

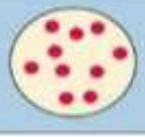
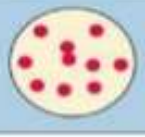
- Mendelian inheritance describe
  - patterns that obey two laws
    - Law of segregation
    - Law of independent assortment
  - Includes **simple Mendelian inheritance**
    - A single gene with two different alleles
    - Alleles display a simple dominant/recessive relationship

MENDELIAN INHERITANCE

- Alternative forms of a gene are called **alleles**.
- **Mutation** is the source of alleles.
- The **wild-type** allele is the one that occurs most frequently in nature and is usually, but not always, **dominant**.

CODOMINANCE

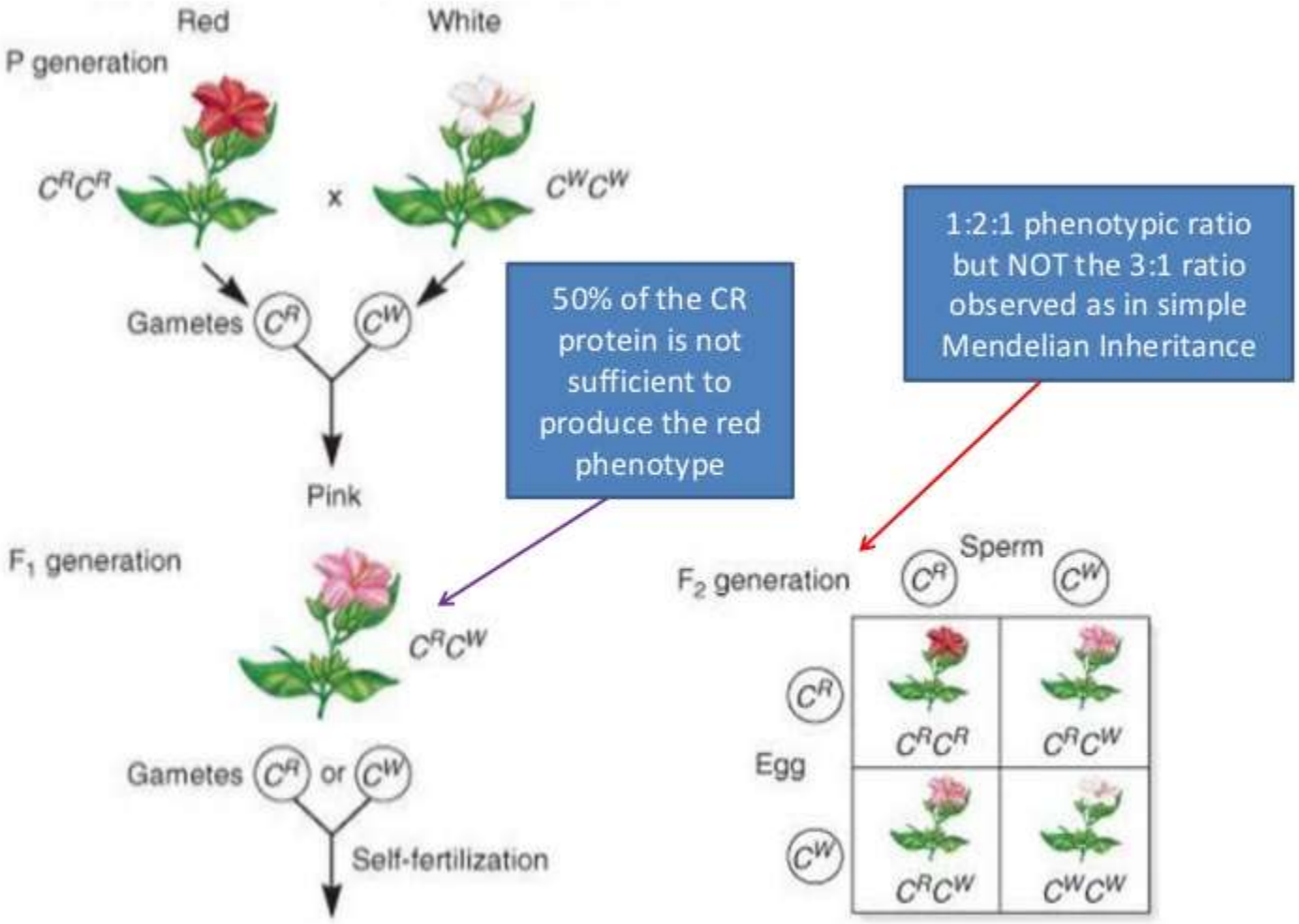
- Any given gene may have more than two alleles and the phenotype of both alleles are in heterozygote.
- Two alleles are expressed
- Do not blend the phenotype
- ‘Co’ – means together
- Co-dominance = both alleles are dominant
  - Example: different blood types and group antigens

Blood Group (Phenotype)	Genotypes	Antibodies Present in Blood	Reaction When Blood from Groups Below Is Mixed with Antibodies from Groups at Left			
			O	A	B	AB
O	ii	Anti-A Anti-B				
A	$I^A I^A$ or $I^A i$	Anti-B				
B	$I^B I^B$ or $I^B i$	Anti-A				
AB	$I^A I^B$	—				

- Also an example of multiple alleles, will be explain further later

INCOMPLETE DOMINANCE

- Heterozygotes sometimes display a phenotype intermediate between the homozygotes
  - e.g., Flower color in the four-o'clock, snapdragons, carnations, etc.
  - Homozygous red (C^RC^R) x homozygous white (C^WC^W)
    - F_1 offspring (C^RC^W) are heterozygous and pink
    - F_2 offspring display 1:2:1 phenotypic and genotypic ratios

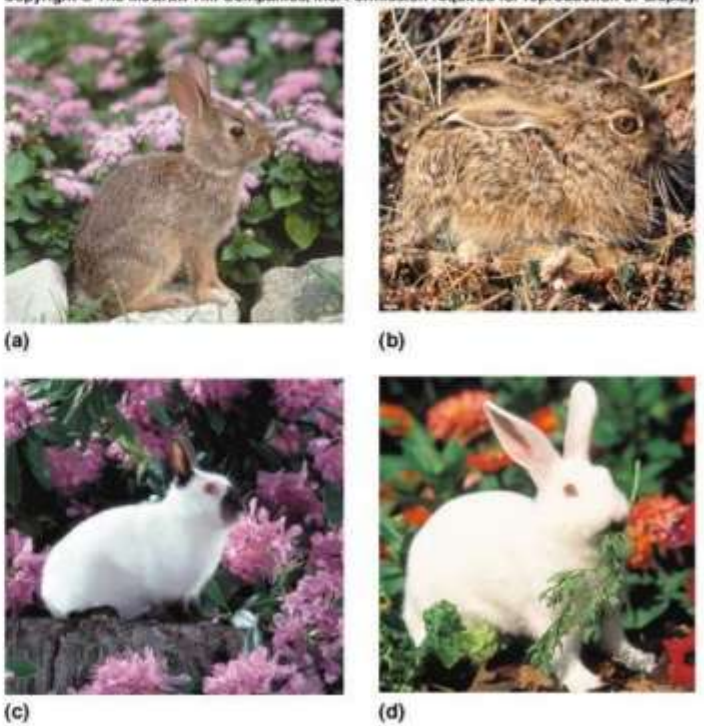

Red
White
P generation
C^RC^R
x
C^WC^W
Gametes
C^R
C^W
Pink
F_1 generation
C^RC^W
Gametes
C^R
or
C^W
Self-fertilization
50% of the CR protein is not sufficient to produce the red phenotype
1:2:1 phenotypic ratio but NOT the 3:1 ratio observed as in simple Mendelian Inheritance
F_2 generation
Sperm
C^R
C^W
Egg
C^R
C^W
C^RC^R
C^RC^W
C^RC^W
C^WC^W

MULTIPLE ALLELES

- Individuals possess two copies of each gene
  - At most, they possess two different alleles
- Means there are same/more than three alleles
- The situation exclude the dominant and recessive effects
- All the alleles show own effects in inheritance
- Eg. Blood type and hair colour

MULTIPLE ALLELES (cont)

- Coat color in rabbits is determined by alleles of the "C" gene
  - Four different alleles exist
    - C = full coat color
    - c^{ch} = chinchilla
    - c^{h} = himalayan
    - c = albino
  - Any particular rabbit possesses only two alleles



MULTIPLE ALLELES (cont)

- Dominant/recessive relationships between coat color alleles
  - *C* is dominant to c^{ch}, c^{h}, and *c*
  - c^{ch} is recessive to *C*, but dominant to c^{h}, and *c*
  - c^{h} is recessive to *C* and c^{ch}, but dominant *c*
  - *c* is recessive to *C*, c^{ch}, c^{h}

$$C > c^{ch} > c^{h} > c$$

MULTIPLE ALLELES (cont)

- $\underline{c^{ch}c}$ *x* $\underline{Cc^{h}}$

	c^{ch}	c
C	Cc^{ch}	Cc
c^{h}	$C^{ch}c^{h}$	$c^{h}c$

- Genotypes:
  - 1 Cc^{ch} :1 Cc : 1 $C^{ch}c^{h}$: 1 $c^{h}c$
- Phenotypes:
  - 2 Full: 1 Chinchilla: 1Himalayan

GENES COMPLEX INTERACTION

1. Epistasis
2. Polygenic Inheritance

EPISTASIS

Defined as:

- An inheritance pattern in which the alleles of one gene mask the phenotypic effects of the alleles of another genes

EPISTASIS:

- The genes whose phenotype is expressed is said to be epistatic, while the phenotype altered or suppressed is said to be hypostatic.
- **Epistasis** can be contrasted with dominance, which is an interaction between alleles at the same gene locus.
- Epistasis is often studied in relation to Quantitative Trait Loci (QTL) and polygenic inheritance

P_1 Pea Comb X Rose Comb
PPrr ppRR

F_1 All Walnut Combs
PpRr

When these F_1 birds are crossed, all four phenotypes are observed:

F_2	PR	Pr	pR	pr
PR	PPRR	PPRr	PpRR	PpRr
Pr	PPRr	PPrr	PpRr	Pprr
pR	PpRR	PpRr	ppRR	ppRr
pr	PpRr	Pprr	ppRr	pprr

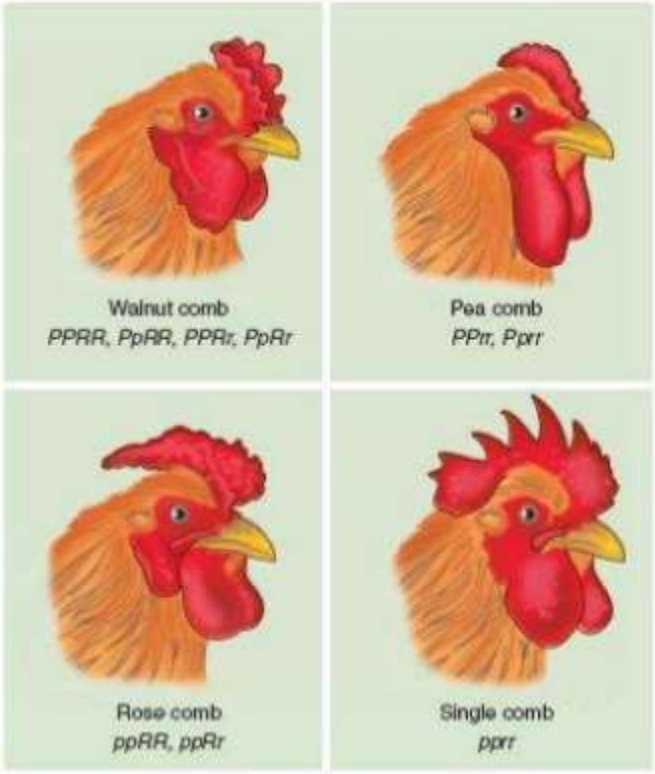
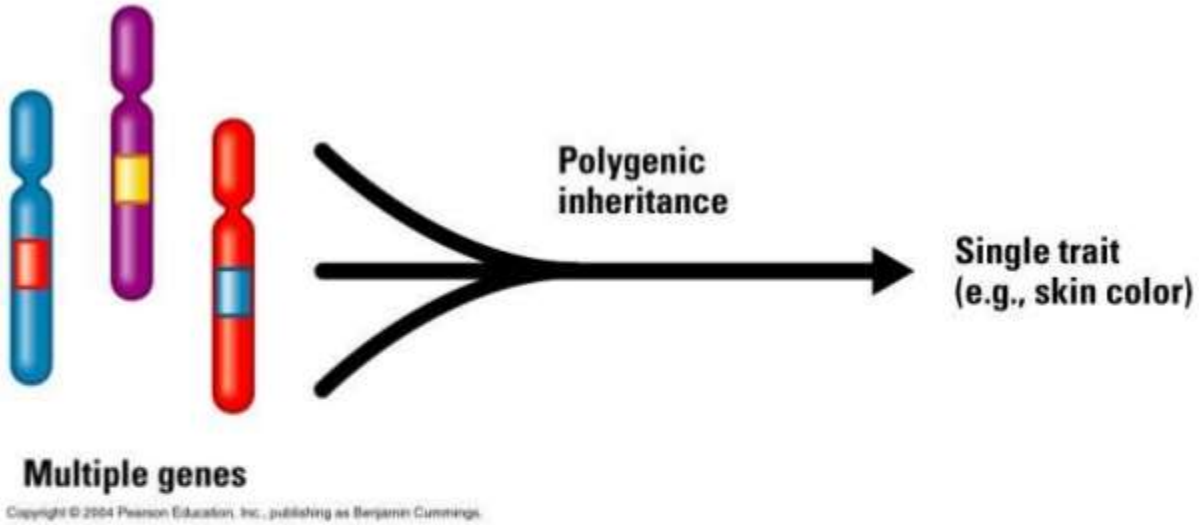


FIGURE 10-20 **Gene interaction in chickens.**
Two gene pairs govern four chicken comb phenotypes. Chickens with walnut combs have the genotype *P_R_*. Chickens with pea combs have the genotype *P_rr*, and those with rose combs have the genotype *ppR_*. Chickens that are recessive for both genes, *pprr*, have a single comb. (The blanks can be either dominant or recessive alleles.)

POLYGENIC INHERITANCE

- This term is use to refer to inheritance of quantitative traits, traits which are influenced by multiple genes and not just one.
- Because many traits are spread out across the continuum, rather than being divided into black and white differences, polygenic inheritance helps to explain the way in which these traits are inherited and focused.
- A related concept is **pleiotropy**, an instance where one gene influences multiple traits (phenotypes).



- However, in the 20th century, people were well aware that most traits are too far complex to be determined by a single gene, and the idea of polygenic inheritance was born.

POLYGENIC INHERITANCE

- One easily understood example of polygenic inheritance is **height**. People are not just short or tall; they have a variety of heights which run along a spectrum.

- Furthermore, height is also influenced by **environment**; someone born with tall genes could become short due to malnutrition or illness, for example, while someone born with short genes could become tall through **genetic therapy.**

DON'T GET CONFUSED!

- Multiple alleles=more than two forms of the same gene in the population e.g blood type

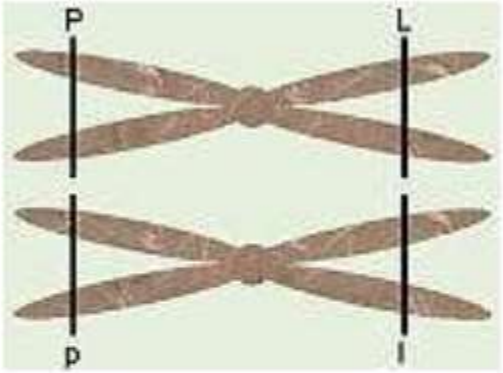
- Polygenic traits=more than one gene contributes to the phenotype

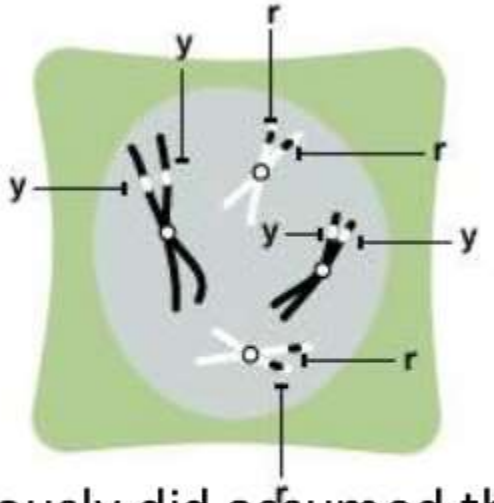
POLYGENIC INHERITANCE (cont)

Examples in Humans

- Weight
- Height
- Eye colour
- Intelligence
- Behaviour
- Skin colour

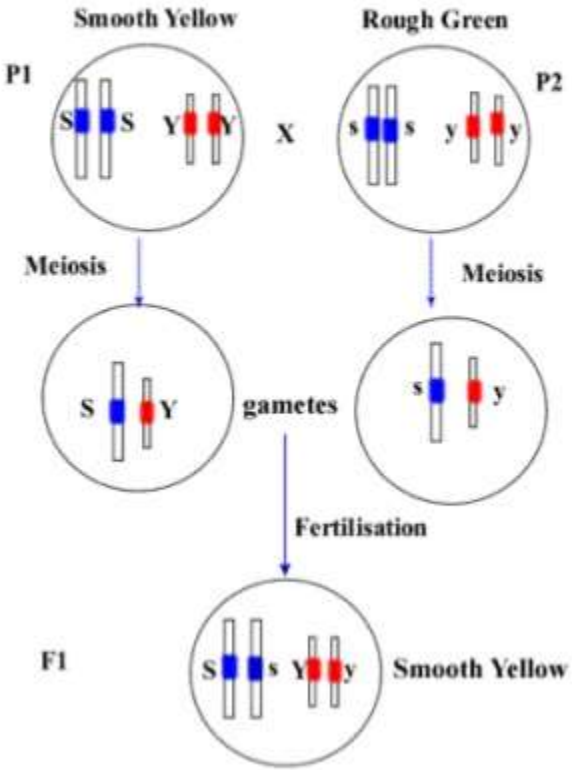
LINKED GENES





- The dihybrid cross we previously did assumed the genes were on different pairs of chromosomes.
- Now, we want to look at an example where the genes involved are on the same chromosome.

Dihybrid cross



Linked genes cross

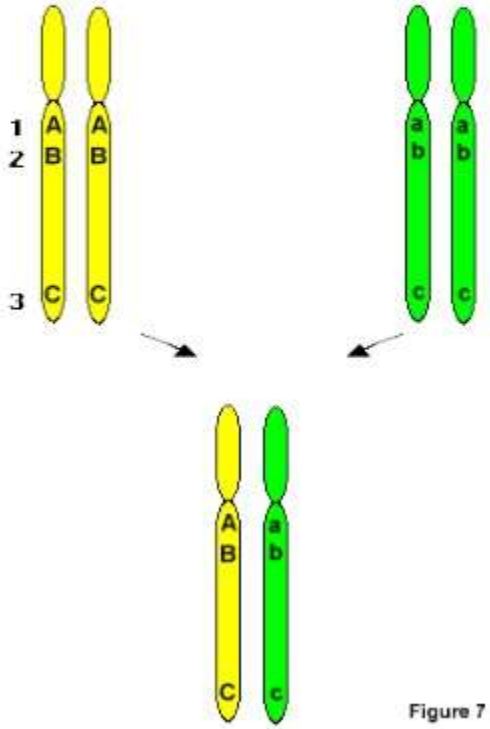


Figure 7

SEX LINKED GENES

- This is **sex-linked genes**, genes located on *one* of the sex chromosomes (X or Y) but not the other.
- Since, typically the X chromosome is longer, it bears a lot of genes not found on the Y chromosome, thus most sex-linked genes are **X-linked genes**.

- One example of a sex-linked gene is fruit fly eye colour.
- An X chromosome carrying a normal, dominant, red-eyed allele would be symbolized by a plain **X**, while the recessive, mutant, white-eyed allele would be symbolized by **X'** or **X^w**.
- A fly with genotype XX' would normally be a female with red eyes, yet be a **carrier** for the white-eyed allele.
- Because a male typically only has one X chromosome, he would normally be either XY and have normal, red eyes, or X'Y and have white eyes.
- The only way a female with two X chromosomes could have white eyes is if she would get an X' allele from both parents making her X'X' genotype. The cross between a female carrier and a red-eyed male would look like this:

	X	Y
X	XX	XY
X’	XX’	X’Y

SEX LINKED GENES (cont)

SEX LIMITED TRAIT

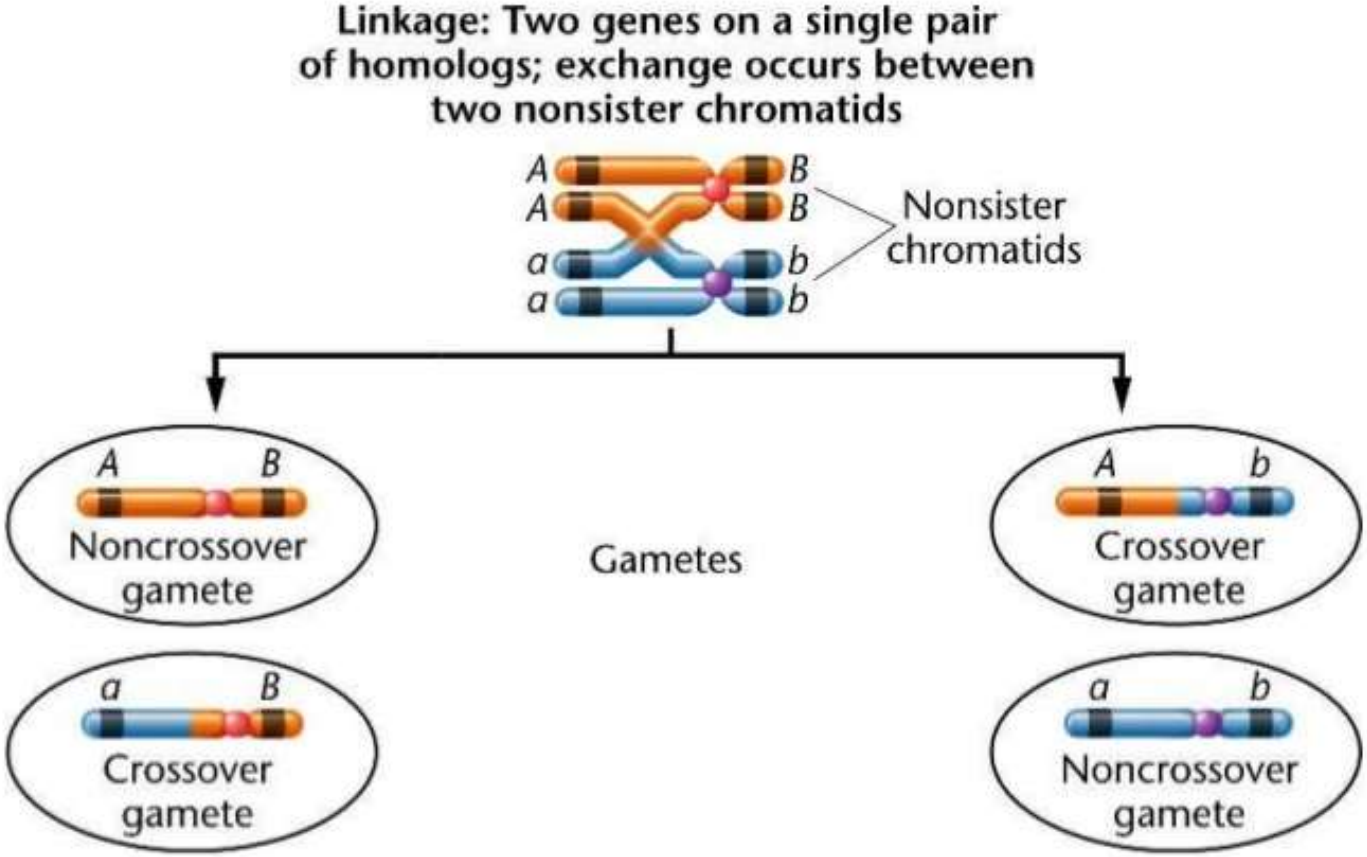
- Affects a structure or function of the body that is present in **only** male or **only** female
- E.g. Growth of beard or breast

SEX INFLUENCED TRAIT

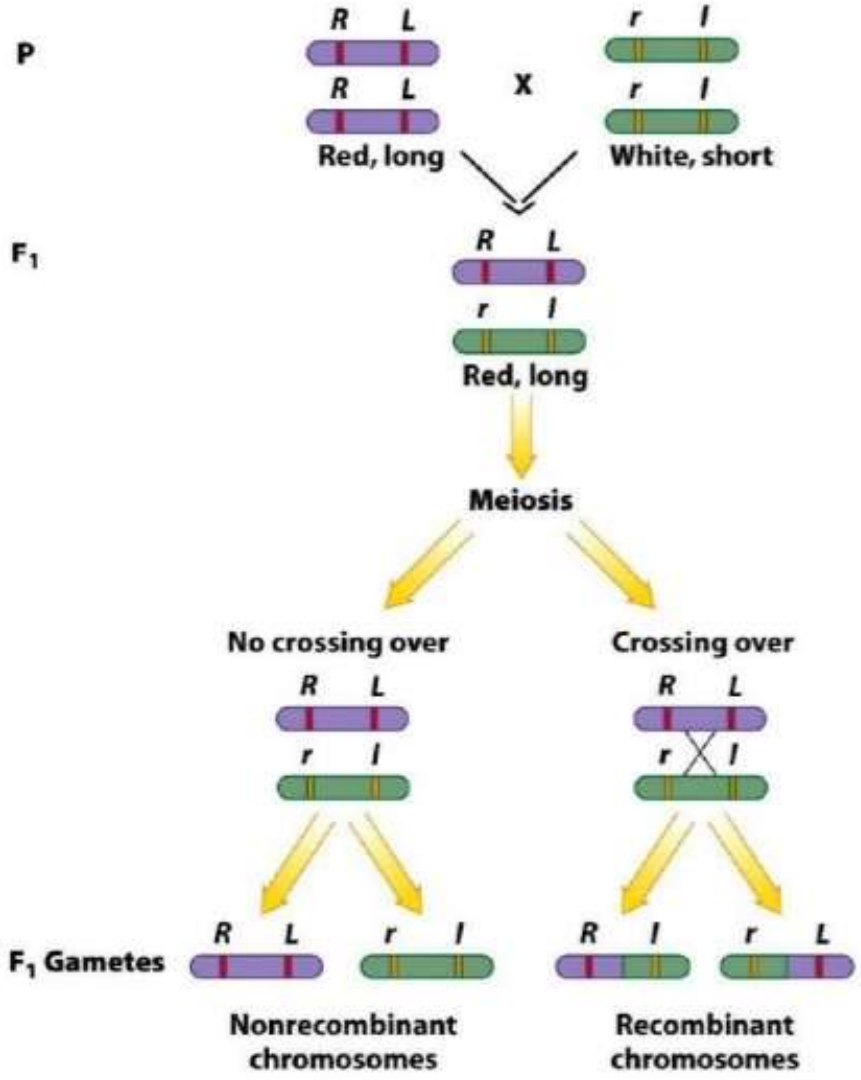
- An allele that is dominant in one sex and recessive in the other
- E.g. Baldness
- Heterozygous male is bald, heterozygous female is not

CROSSING OVER

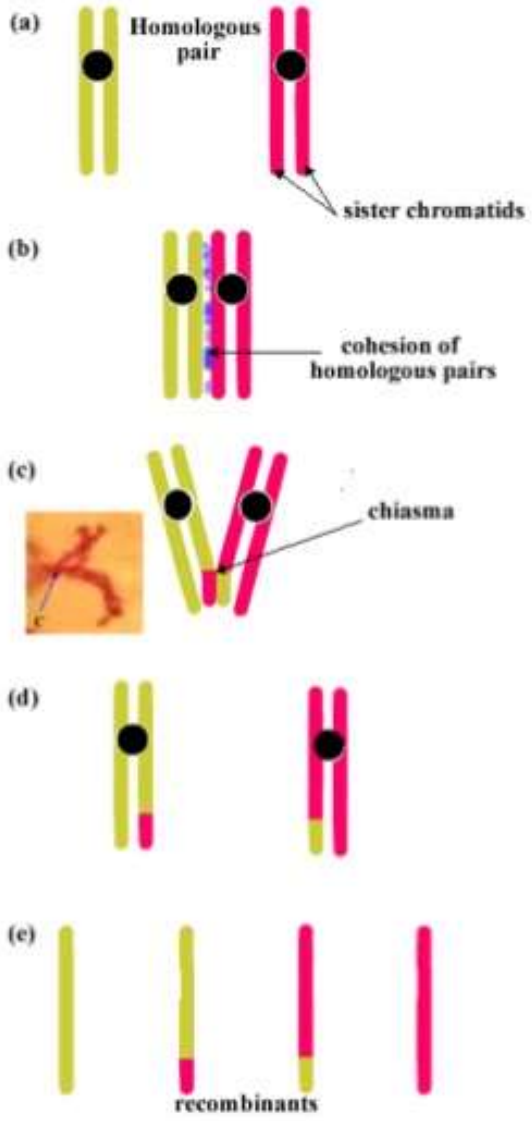
- Even though the alleles for different genes may be linked along the same chromosome, the linkage can be altered during meiosis.
- In diploid eukaryotic species, homologous chromosomes can exchange pieces with each other, a phenomenon called **crossing over**.
- This event occurs during **prophase of meiosis I.**



Combination alleles = genetic recombinant


P
R L
R L
Red, long
X
r l
r l
White, short
F1
R L
r l
Red, long
Meiosis
No crossing over
Crossing over
R L
r l
R L
r l
F1 Gametes
R L
r l
R l
r L
Nonrecombinant chromosomes
Recombinant chromosomes

- Chiasma is the point where chromatids become criss-crossed and the chromosome exchange segements.
- New combinantion arise from crossing over resulting in recombination and passed during the gamete formation.
- When meiosis is over 2 chromosome separated to become individual chromatids and produce 4 genetically different chromosome.



GENE MAPPING

- Also known as chromosome mapping, to determine linear order and distance of separation among genes that are linked to each other along the same chromosome.

GENE MAPPING

- Genetic map benefits:
  - Locate human gene that causing diseases, this information can be used to diagnose and someday treat inherited human diseases.
  - Predict likelihood that a couple will produce children with certain inherited diseases.
  - Also important in agriculture – help in improving crops/animal through selective breeding.