

FISH GENETICS AND BREEDING

INTRODUCTION TO GENETICS & MENDEL'S LAWS



**Presented By,
Dr. Mangesh M. Bhosale**

- Introduction to Genetics and Heredity
- Genetic terminology (glossary)
- Gregor J. Mendel : Info & Principles
- Test cross
- Beyond Mendelian genetics : incomplete dominance



Introduction to Genetics

- **GENETICS** : Branch of biology that deals with the study of heredity and variation of organisms at gene level.
- **Chromosomes** carry the hereditary information (genes)
 - Arrangement of nucleotides in DNA
 - DNA → RNA → Proteins

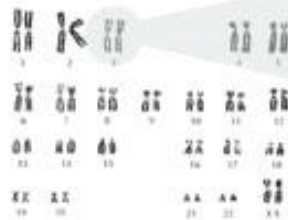


- Chromosomes (and genes) occur in pairs
- ## Homologous Chromosomes
- New combinations of genes occur in sexual reproduction

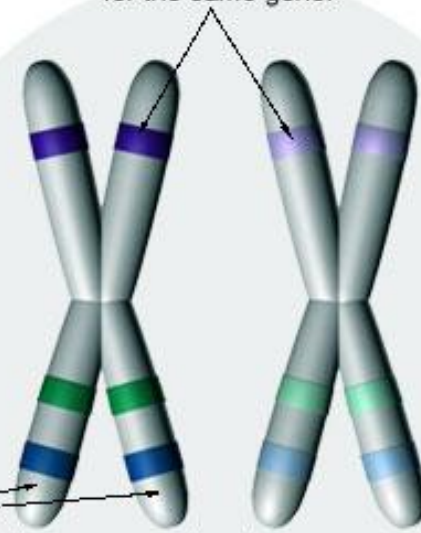
Figure B-11: Homologous Chromosomes

Homologous chromosomes contain DNA that codes for the same genes. In this example, both chromosomes have all the same genes in the same locations (represented with colored strips), but different 'versions' of those genes (represented by the different shades of each color).

Homologous regions code for the same gene.



Sister chromatids are exact replicas... but homologous chromosomes are not.



Gregor Johann Mendel

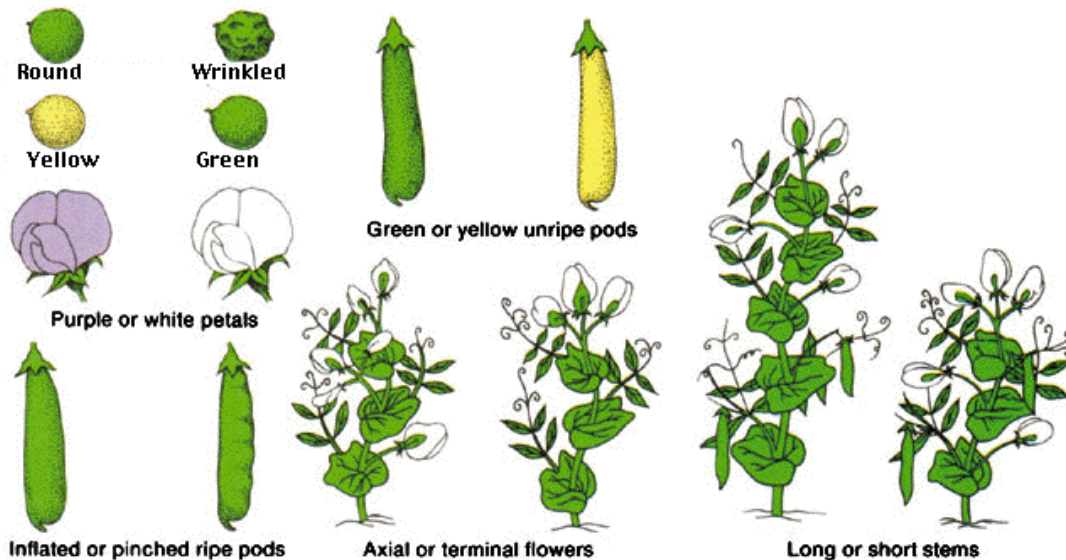
- Austrian Monk, born in what is now Czech Republic in 1822
- Prior to Mendel, heredity was regarded as a "blending" process.



Gregor Mendel

Mendel's peas

- Mendel selected at seven traits of pea plants.

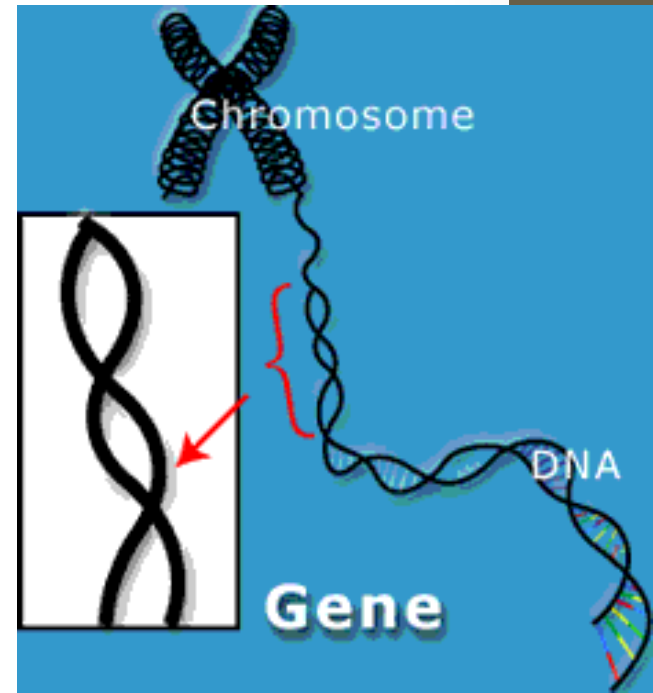


Trait	Stem length	Pod shape	Seed shape	Seed color	Flower position	Flower color	Pod color
Characteristics	Tall	Inflated	Smooth	Yellow	Lateral	Purple	Green
	Dwarf	Constricted	Wrinkled	Green	Terminal	White	Yellow

Constricted

Genetics terminologies :

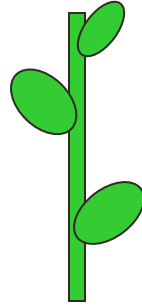
- **Gene** –a section of DNA encoding a protein
- **Genome** – the entire set of genes in an organism
- **Alleles** –genes occupy same position on homologous chromosomes and cover same trait.
- **Locus** – a fixed location of a gene.



- **Homozygous** : identical genes for a character.
- **Heterozygous** –two genes for a characteristic.
- **Dominant** – the allele of a gene that masks expression of an alternate allele; heterozygous condition.
- **Recessive** – an allele that is masked by a dominant allele;
- **Heterozygous**: won't appear
- **Homozygous**: appear.
- **Genotype** – the genetic makeup
- **Phenotype** – the physical appearance (Genotype + environment)

Monohybrid cross for stem length:

P = parentals
true breeding,
homozygous plants:

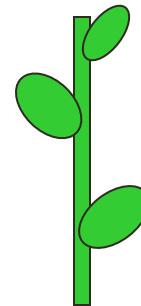


$TT \times tt$
(tall) (dwarf)



F₁ generation
is heterozygous:

Tt
(all tall plants)



Punnett square

- "split" the letters of the genotype for each parent & put them "outside" the p-square
- Determine the possible genotypes of the offspring by filling in the p-square
- Summarize results

$TT \times tt$

	T	T
<i>t</i>	Tt	Tt
<i>t</i>	Tt	Tt

Genotypes:
100% Tt

Phenotypes:
100% Tall plants

Monohybrid cross: F₂ generation

- If you let the F₁ generation self-fertilize, the next monohybrid cross would be:

$$\begin{array}{c} \mathbf{Tt} \times \mathbf{Tt} \\ \text{(tall)} \quad \text{(tall)} \end{array}$$

	T	<i>t</i>
T	TT	T<i>t</i>
<i>t</i>	T<i>t</i>	<i>tt</i>

Genotypes:

1 TT= Tall

2 T*t* = Tall

1 *tt* = dwarf

Genotypic ratio= 1:2:1

Phenotype:

3 Tall

1 dwarf

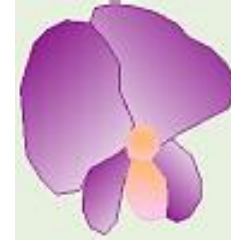
Phenotypic ratio= 3:1

Another example: Flower color

For example, flower color:

P = purple (dominant)

p = white (recessive)



If you cross a homozygous Purple (PP) with a homozygous white (pp):

$PP \times pp$



Pp



ALL PURPLE (Pp)

Cross the F1 generation:

$Pp \times Pp$

	P	<i>p</i>
P	PP	P<i>p</i>
<i>p</i>	P<i>p</i>	<i>pp</i>

Genotypes:

1 PP

2 Pp

1 pp

Phenotypes:

3 Purple

1 White

Mendel's Principles

- **1. Principle of Dominance:**

One allele masked another, one allele was dominant over the other in the F_1 generation.

- **2. Principle of Segregation:**

When gametes are formed, the pairs of hereditary factors (genes) become separated, so that each sex cell (egg/sperm) receives only one kind of gene.

Dihybrid crosses

- Mating that involve parents that differ in **two** genes (two independent traits)

For example, flower color:

P = purple (dominant)

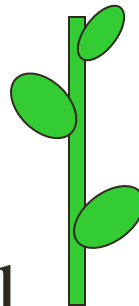


p = white (recessive)



and stem length:

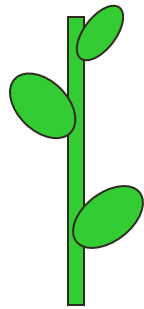
T = tall



t = short



Dihybrid cross: flower color and stem length



TT PP
(tall, purple)

× tt pp

(short, white)



Possible Gametes for parents

tp

tp

tp

tp

(TP) and (tp)

TP

TtPp

TtPp

TtPp

TtPp

TP

TtPp

TtPp

TtPp

TtPp

TP

TtPp

TtPp

TtPp

TtPp

TP

TtPp

TtPp

TtPp

TtPp

F1 Generation: All tall, purple flowers (*Tt Pp*)

Dihybrid cross F_2

If F_1 generation is allowed to self pollinate, Mendel observed 4 phenotypes:

$$\begin{array}{cc} Tt Pp & \times & Tt Pp \\ \text{(tall, purple)} & & \text{(tall, purple)} \end{array}$$

Possible gametes:

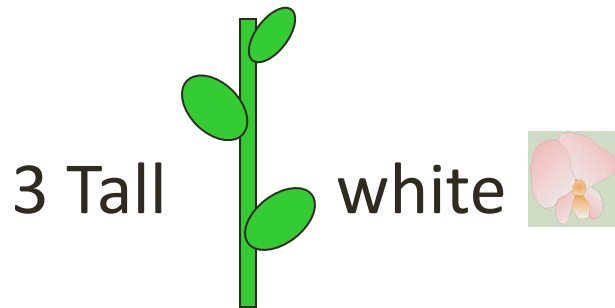
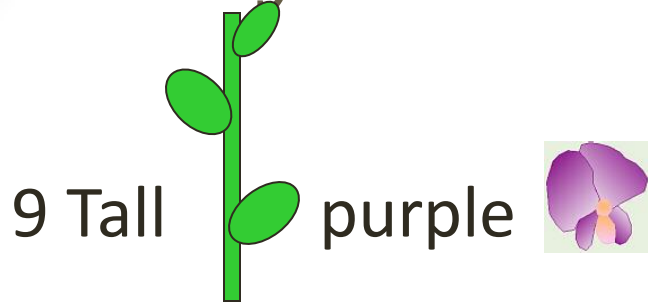
$TP \quad Tp \quad tP \quad tp$

	TP	Tp	tP	tp
TP	$TT PP$	$TT Pp$	$Tt PP$	$Tt Pp$
Tp	$TT Pp$	$TT pp$	$Tt Pp$	$Tt pp$
tP	$Tt PP$	$Tt Pp$	$tt PP$	$tt Pp$
tp	$Tt Pp$	$Tt pp$	$tt Pp$	$tt pp$

Four phenotypes observed

Tall, purple (9); Tall, white (3); Short, purple (3); Short white (1)

Dihybrid cross



	TP	Tp	tP	tp
TP	TTPP	TTPp	TtPP	TtPp
Tp	TTPp	TTpp	TtPp	Ttpp
tP	TtPP	TtPp	ttPP	ttPp
tp	TtPp	Ttpp	ttPp	ttpp

Phenotype Ratio = 9:3:3:1

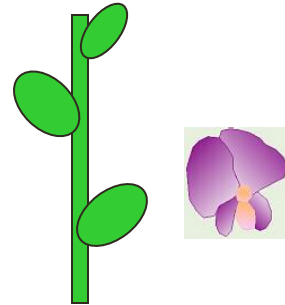
Dihybrid cross: 9 genotypes

Genotype ratios (9):

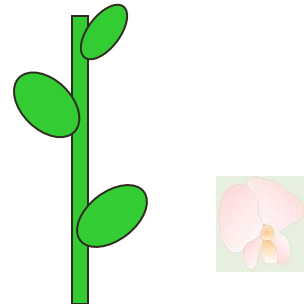
1	$TTPP$
2	$TTPp$
2	$TtPP$
4	$TtPp$
1	$TTpp$
2	$Ttpp$
1	$ttPP$
2	$ttPp$
1	$tttp$

Four Phenotypes:

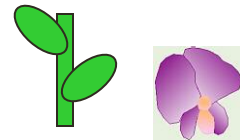
Tall, purple (9)



Tall, white (3)



Short, purple (3)



Short, white (1)



- Based on these results, Mendel postulated the

3. Principle of Independent Assortment:

“Members of one gene pair segregate independently from other gene pairs during gamete formation”

Genes get shuffled – these many combinations are one of the advantages of sexual reproduction

Test cross

When you have an individual with an unknown genotype, you do a **test cross**.

Test cross: Cross with a homozygous recessive individual.

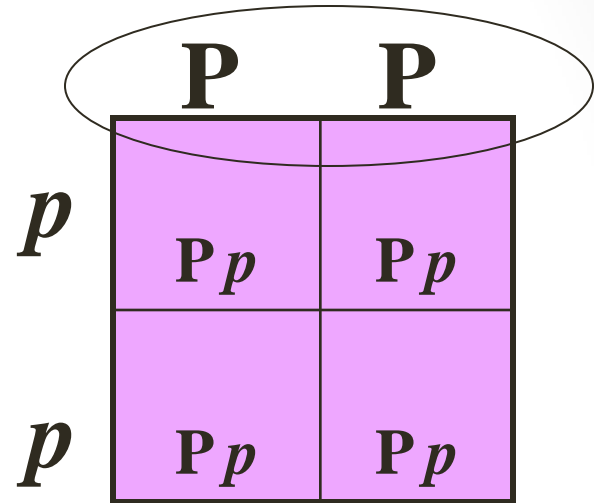
For example, a plant with **purple** flowers can either be **PP** or **Pp**... therefore, you cross the plant with a *pp* (white flowers, homozygous recessive)

$P ? \times pp$

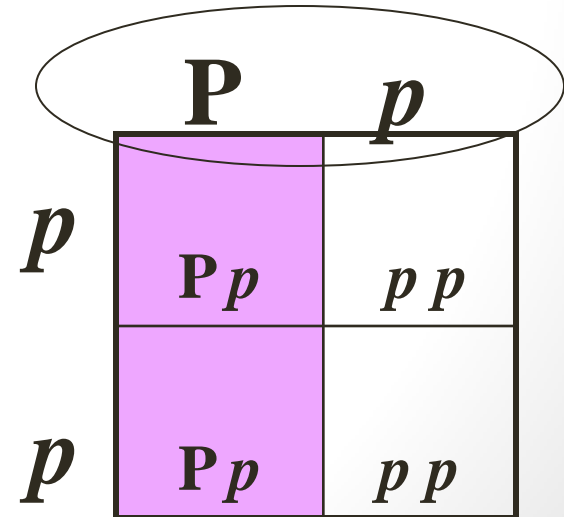


Test cross

- If you get all 100% purple flowers, then the unknown parent was PP...

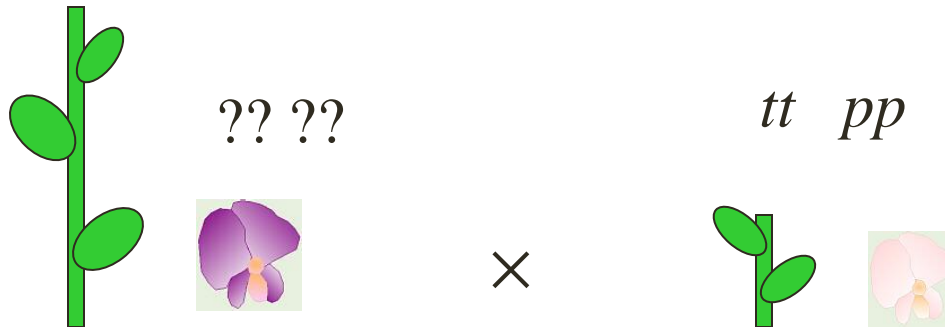


- If you get 50% white, 50% purple flowers, then the unknown parent was Pp...



Dihybrid test cross??

If you had a tall, purple plant, how would you know what genotype it is?



1. $TTPP$
2. $TTPp$
3. $TtPP$
4. $TtPp$

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...

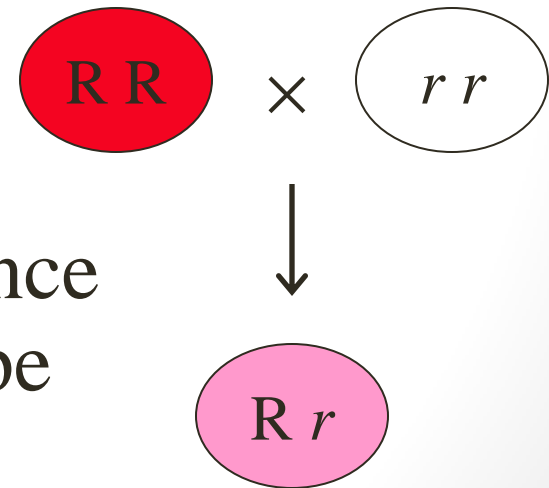
Incomplete Dominance

Snapdragon flowers come in many colors.



If you cross a red snapdragon (RR) with a white snapdragon (rr)
You get PINK flowers (Rr)!

Genes show incomplete dominance
when the heterozygous phenotype
is intermediate.



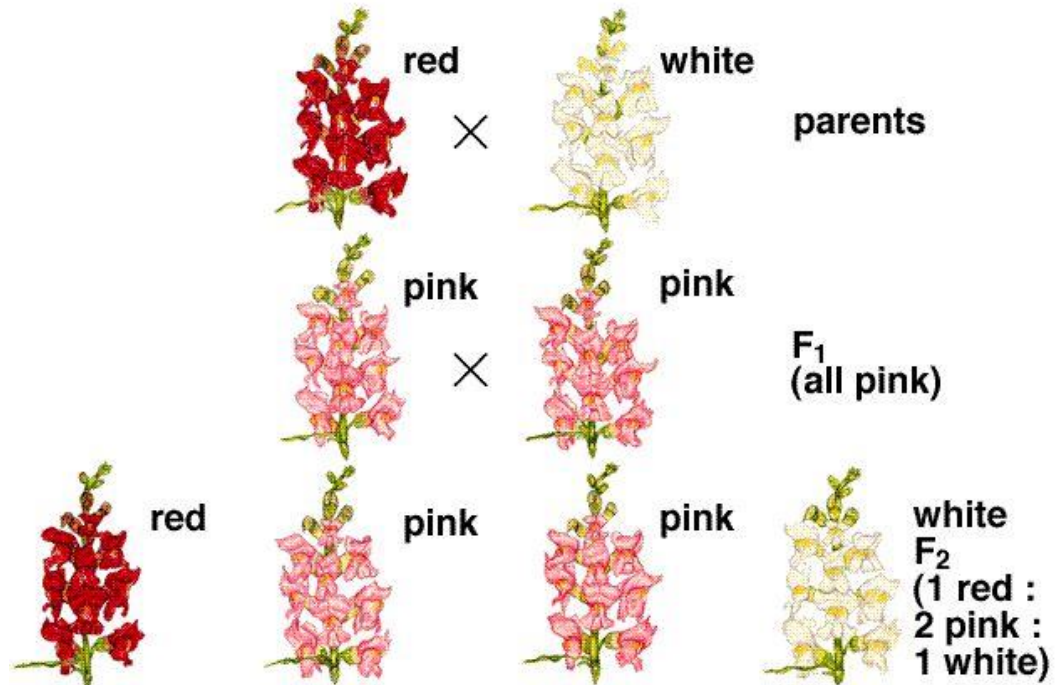
Incomplete dominance

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

Kingsley R. Stern, Botany Visual Resource Library © 1997 The McGraw-Hill Companies, Inc. All rights reserved.

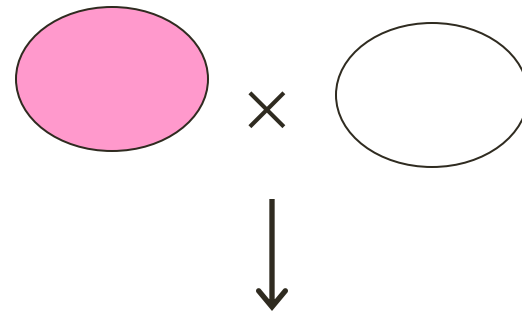
Absence of Dominance

	R	<i>r</i>
R	R R	R <i>r</i>
<i>r</i>	R <i>r</i>	<i>r r</i>

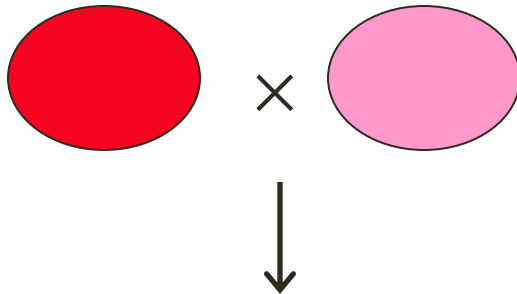


Incomplete dominance

What happens if you cross a pink with a white?



A pink with a red?



Summary of Genetics

- Chromosomes carry hereditary info (genes)
- Chromosomes (and genes) occur in pairs
- New combinations of genes occur in sexual reproduction
- Monohybrid vs. Dihybrid crosses
- Mendel's Principles:
 - Dominance: one allele masks another
 - Segregation: genes become separated in gamete formation
 - Independent Assortment: Members of one gene pair segregate independently from other gene pairs during gamete formation

Thanks! Remember: