Monohybrid inheritance only involves one gene, one trait

Completed

Genetic Basis for Mendel's Experiment

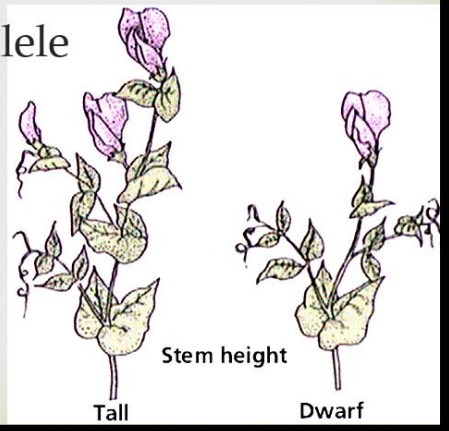
Key

T – allele for tall plant

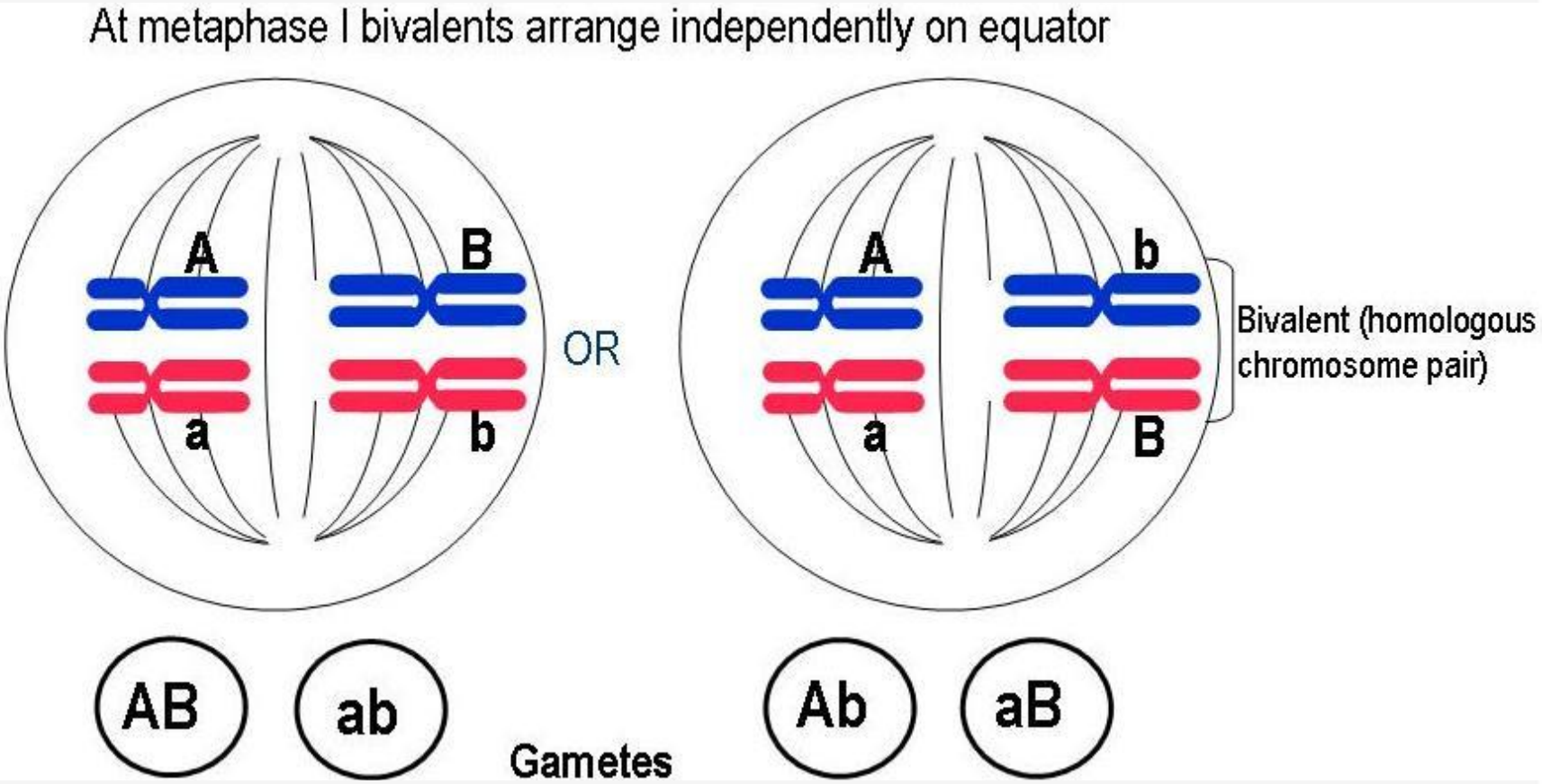
t – allele for short plant

Plant height

- Allele for tallness (T) is dominant to allele for shortness (t)



Dihybrid inheritance involves TWO genes, TWO traits

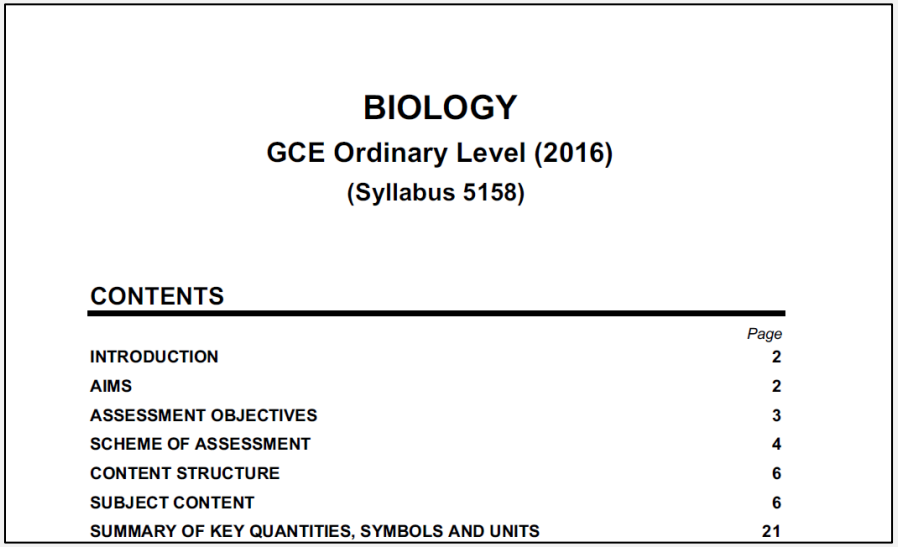


Test Crosses

Page 16

What I know … 01

- 15(c)
  Predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms homozygous, heterozygous, F1 generation and F2 generation



BIOLOGY

GCE Ordinary Level (2016)

(Syllabus 5158)

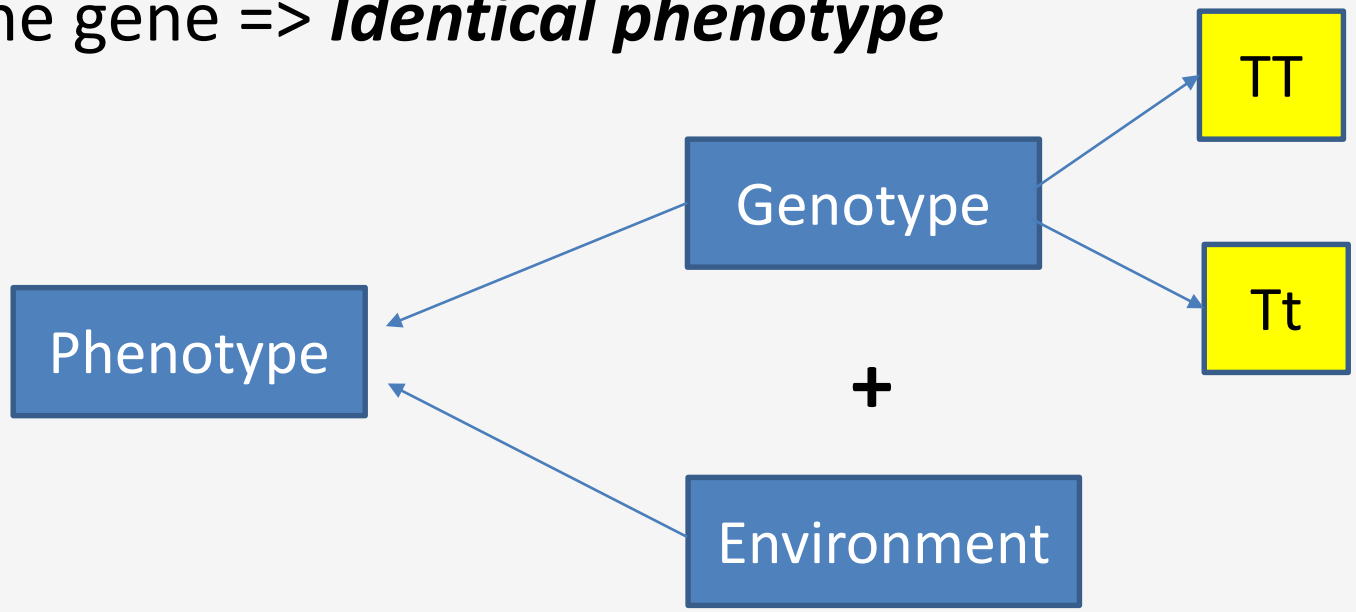
CONTENTS

What I need to know … 01

- 2(o)
  Use genetic diagrams to solve problems involving test crosses

Test Cross

- An individual that shows the **effect of a dominant allele** can have **two** possible **genotypes**.
- Example: A **tall** pea plant could either be homozygous dominant (**TT**) or heterozygous (**Tt**) for the gene => ***Identical phenotype***



What can be done to determine the genotype of a tall pea plant?

- A **TEST CROSS** can be carried out.
- In a test cross, the individual of unknown genotype (**TT or Tt**) showing the effect of a dominant allele is crossed with one who is homozygous recessive **e.g. tt**, at the locus in question.

Worked Example

- Carry out a genetic cross to determine the genotype of a tall plant
- Ans : **test-cross**

<u>Key:</u>

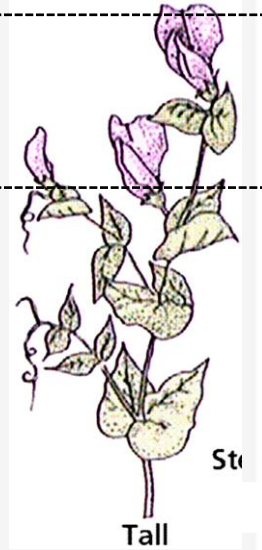
Let T represent the allele for tall offspring

Let t represents the allele for short offspring

The allele for tall offspring (T) is **dominant** to the allele for short offspring (t)

A test cross on a tall pea plant whose genotype is **TT** will produce only tall offspring

Parental phenotype	**:**	**Tall plant**		**Short plant**
Parental genotype	**:**	**TT**	**X**	**tt**
Parental gametes	**:**	**T**		**t**
Genotype of offspring	**:**	**Tt**		
Phenotype of offspring	**:**	**All tall plants**		



A test cross on a tall pea plant whose genotype is **Tt** will produce tall and short offspring in the ratio of 1 : 1

Parental phenotype	:	**Tall plant**		**Short plant**
Parental genotype	:	**Tt**	**X**	**tt**
Parental gametes	:	**T** **t**		**t**
Genotype of offspring	:	**Tt**		**tt**
Phenotype of offspring	:	**Tall plant**		**Short plant**
Phenotypic ratio of offspring	:	**1**	**:**	**1**

Practice 1

In Dalmatian dogs, the **allele for black spots is dominant to the allele for brown spots**. A breeder wanted to know the genotype of a black spotted female Dalmatian.

The **black spotted female was crossed with a brown spotted male**, and a **litter of 2 black puppies** was produced. The breeder concluded that the female Dalmatian was homozygous for black spots.

Explain if the breeder's conclusion was correct.

Practice 1

In Dalmatian dogs, the allele for black spots is dominant to the allele for brown spots.

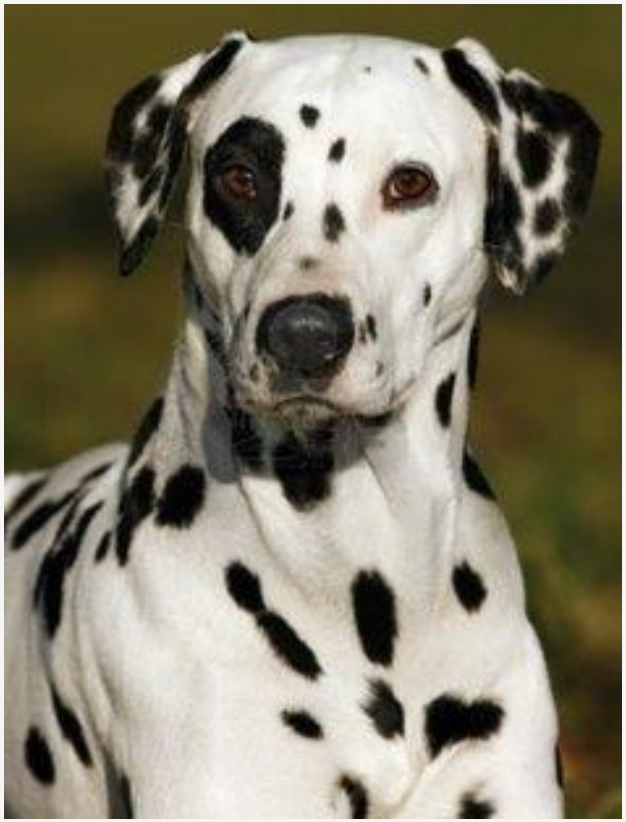
A breeder wanted to know the genotype of a black spotted female Dalmatian. The black spotted female was crossed with a brown spotted male, and a litter of 2 black puppies was produced.

The breeder concluded that the female Dalmatian was homozygous for black spots. Explain if the breeder's conclusion was correct.

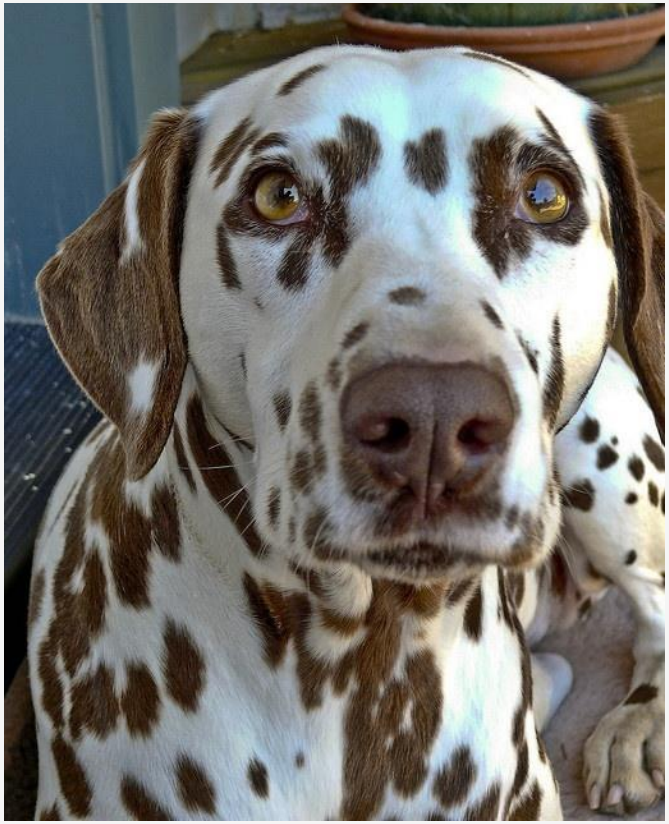
Genotype of black spotted female can be BB or Bb

Test cross!

Practice 1 (5 min)



X



Practice 1

Key:

Let B represent the allele for black spots

Let b represent the allele for brown spots

The allele for black spots (B) is **dominant** to the allele for brown spots (b)

Scenario 1 : if black spotted female is homozygous dominant for colour of spots

Parental phenotype	**:**	**Black spots**		**Brown spots**
Parental genotype	**:**	**BB**	**X**	**bb**
Parental gametes	**:**	**B**		**b**
Genotype of F1	**:**	**Bb**		
F1 phenotypic ratio	**:**	**All with black spots**		

Scenario 2 : if black spotted female is **heterozygous** for colour of spots

Parental phenotype	:	**Black spots**		**Brown spots**
Parental genotype	:	**Bb**	**X**	**bb**
Parental gametes	:	**B** **b**		**b**
F1 genotype	:	**Bb**		**bb**
F1 phenotype	:	**Black spots**		**Brown spots**
F1 phenotypic ratio	"	**1**	**:**	**1**

Is the dog breeder's conclusion correct?

Practice 1

- Breeder could be either **right or wrong**

The black spotted female can have either the

- genotype of homozygous dominant alleles, **BB** (in scenario 1) or
- genotype of heterozygous alleles, **Bb** (in scenario 2)

to produce offspring with the phenotype of black spotted appearance.

Practice 1

In Scenario 1,

- the black spotted female with **homozygous dominant alleles (BB)** will produce **offspring, all** of which were **black spotted when test crossed** with the homozygous recessive brown spotted male (bb).
- For every pregnancy, we are 100% sure that the black spotted female will produce black spotted offspring in the test cross.

Scenario 1 : if black spotted female is homozygous dominant for colour of spots

Parental phenotype	**:**	**Black spots**		**Brown spots**
Parental genotype	**:**	**BB**	**X**	**bb**
Parental gametes	**:**	**B**		**b**
Genotype of F1	**:**	**Bb**		
F1 phenotypic ratio	**:**	**All with black spots**		

Practice 1

In Scenario 2,

- the black spotted female with **heterozygous alleles (Bb)** will produce offspring, **half of which (50%)** will have phenotype of **black** spotted appearance while the **other half (50%)** will have phenotype of **brown** spotted appearance.
- There is a **50%** chance that black or brown spotted puppies may be produced at each pregnancy.

Scenario 2 : if black spotted female is **heterozygous** for colour of spots

Parental phenotype	:	**Black spots**		**Brown spots**
Parental genotype	:	**Bb**	**X**	**bb**
Parental gametes	:	**B** **b**		**b**
F1 genotype	:	**Bb**		**bb**
F1 phenotype	:	**Black spots**		**Brown spots**
F1 phenotypic ratio	"	**1**	**:**	**1**

Practice 1

- **As only a small number of black puppies (only two) were involved**, the small number of offspring does **not** provide sufficient evidence to draw conclusion that **ALL** her offspring will be black-spotted since there is the possibility that both puppies reproduced, **by chance**, are black-spotted
- *(recall meiosis and random fusion of gametes during fertilisation)*. In fact, there is a ¼ chance for this to occur (½ x ½).

Test Cross: Dihybrid inheritance

Heterozygous dominant pea plant (RrGg) crossed with heterozygous dominant pea plant (RrGg)

=> ***16 genotypes in F1***

- **Traits: Seed shape & Seed color**
- **Alleles: R round**
  r wrinkled
  G green
  g yellow

Example: Test cross on F1

Heterozygous dominant pea plant crossed with heterozygous dominant pea plant => **9R_G_:3rrG_:3R_gg:1rrgg**

	RG	rG	Rg	rG
RG	RRGG	RrGG	RRGg	RrGg
rg	RrGG	rrGG	RrGg	rrGg
Rg	RRGg	RrGg	RRgg	Rrgg
rg	RrGg	rrGg	Rrgg	rrgg

Example: Test cross on F1

RRGG, RrGg, RRGg, RrGG all show the same phenotype of round and yellow seeds

	RG	rG	Rg	rG
RG	RRGG	RrGG	RRGg	RrGg
rg	RrGG	rrGG	RrGg	rrGg
Rg	RRGg	RrGg	RRgg	Rrgg
rg	RrGg	rrGg	Rrgg	rrgg

Example: Test cross on F1

How to determine the genotype of a plant with round and yellow seeds?

Perform Test cross!
cross the F1 plant (round yellow seeds) with plant that is homozygous recessive for both traits, rrgg

If genotype of F1 is RrGg

Parental phenotypes	:	Round, yellow seeds			Wrinkled green seeds
Parental genotypes	:	RrGg		X	rrgg
Parental gametes	:	RG, rG, Rg, rg			rg
F1 genotype	:	RrGg	rrGg	Rrgg	rrgg
F1 phenotype	:	Round, yellow seeds	Wrinkled yellow seeds	Round, green seeds	Wrinkled green seeds
F1 phenotypic ratio		1	: 1	: 1	: 1

If genotype of F1 is **RRGG**

Parental phenotypes	:	**Round, yellow seeds**		**Wrinkled green seeds**
Parental genotypes	:	**RRGG**	**X**	**rrgg**
Parental gametes	:	**RG**		**rg**
F1 genotype	:	**RrGg**		
F1 phenotype	:	**All Round, Yellow seeds**		

If genotype of F1 is **RrGG**

Parental phenotypes	:	**Round, yellow seeds**		**Wrinkled green seeds**
Parental genotypes	:	**RrGG**	**X**	**rrgg**
Parental gametes	:	**RG** **rG**		**rg**
F1 genotype	:	**RrGg**		**rrGg**
F1 phenotype	:	**Round, yellow seeds**		**wrinkled, yellow seeds**
F1 phenotypic ratio		**1**	**:**	**1**

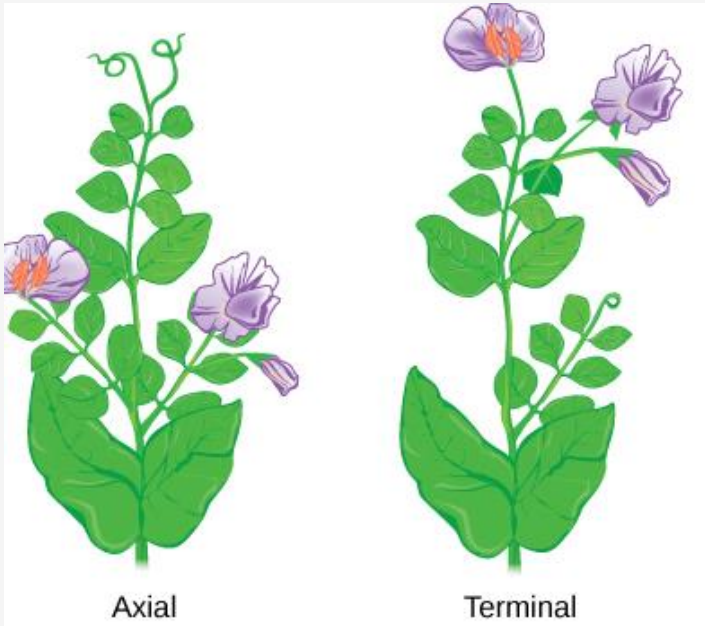
If genotype of F1 is **RRGg**

Parental phenotypes	:	**Round, yellow seeds**		**Wrinkled green seeds**
Parental genotypes	:	**RRGg**	**X**	**rrgg**
Parental gametes	:	**RG** **Rg**		**rg**
F1 genotype	:	**RrGg**		**Rrgg**
F1 phenotype	:	**Round, yellow seeds**		**Round, green seeds**
F1 phenotypic ratio		**1**	**:**	**1**

Practice 2

A plant with **axial purple flowers** is test crossed with a plant that produces **terminal white flowers**.

(Axial flowers and Purple flowers are dominant traits)

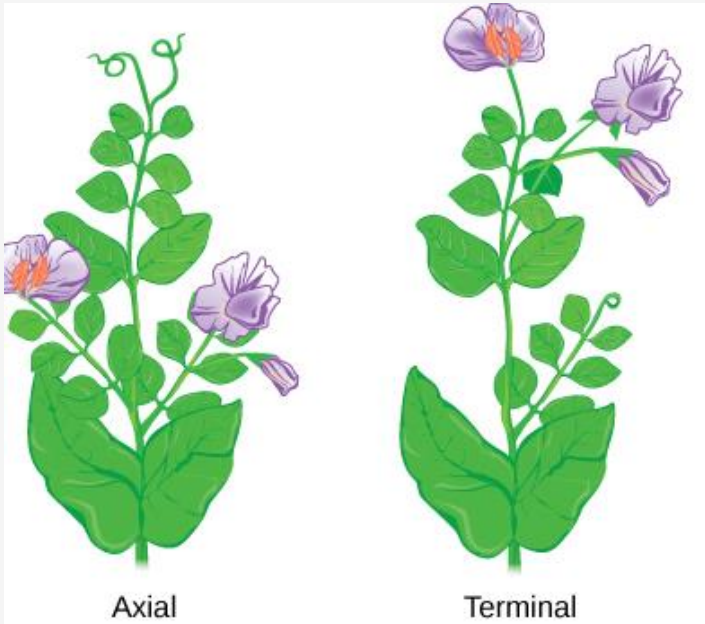


Trait 1 : Location of flowers
Phenotypes : Axial or terminal position

Trait 2 : Colour of flowers
Phenotypes : Purple or white

Practice 2

- Dihybrid cross involving **2 genes** and their alleles



Trait 1 : Location of flowers
Phenotypes : Axial or terminal position

Trait 2 : Colour of flowers
Phenotypes : Purple or white

Practice 2

A plant with axial purple flowers is test crossed with a plant that produces terminal white flowers. (**axial flowers** and **purple flower** are **dominant** traits)

Key:

Let A represent the allele for axial flowers

Let a represent the allele for terminal flowers

Let Q represent the allele for purple flowers

Let q represents the allele for white flowers

The allele for axial flower (A) is **dominant** to the allele for terminal flower (a)

The allele for purple flower (Q) is **dominant** to the allele for white flower (q)

Practice 2 (2 min)

A plant with axial purple flowers is test crossed with a plant that produces terminal white flowers. Given that **axial flowers** and **purple flower** are **dominant** traits…

(a) State the possible genotypes of plants with axial purple flowers

AAQQ
AAQq
AaQQ
AaQq

At least a dominant allele at each gene locus
Ie A_Q_

Practice 2 (5 min)

(b) Show the results of the **test cross** for plant with axial purple flowers if it was a:

(i) homozygous dominant plant and

(ii) the heterozygous plant

Scenario 1 : **Homozygous Dominant plant**

Parental phenotype	:	**Axial purple flower**	**X**	**Terminal white flower**
Parental genotype	:	**AAQQ**	**X**	**aaqq**
Parental gametes	:	**AQ**		**aq**
Genotype of F1	:	**AaQq**		
F1 phenotypic ratio	:	**All axial purple flowers**		

Scenario 2 : **Heterozygous plant**

Parental phenotype	:	**Axial purple flower**		**X**	**Terminal white flower**
Parental genotype	:	**AaQq**		**X**	**aaqq**
Parental gametes	:	**AQ**	**Aq**		**aq**
		aQ	**aq**		
Genotype of F1	:	**AaQq**	**Aaqq**	**aaQq**	**aaqq**
F1 phenotypic ratio	:	**1 axial purple flower : 1 axial white flower : 1 terminal purple flower : 1 terminal white flower**			

Individual showing **effect of a dominant allele**

heterozygous at the gene locus

Test cross with **homozygous recessive**

heterozygous at **BOTH** gene locus

Monohybrid inheritance

2 possible genotypes

Phenotypic ratio **1 : 1**

Dihybrid inheritance

4 possible genotypes

Phenotypic ratio **1:1:1:1**

SUMMARY

Scenario	Phenotypic ratio
Test cross (monohybrid) Heterozygous x homozygous recessive e.g. Aa x aa	**1 : 1**
Test cross (dihybrid) Heterozygous x Homozygous recessive e.g. AaBb x aabb	**1 : 1 : 1 : 1**

SUMMARY

Scenario	Phenotypic ratio
Monohybrid cross Heterozygote x Heterozygote e.g. Aa x Aa	**3 : 1**
Dihybrid cross Heterozygote x Heterozygote e.g. AaBb x AaBb	**9 : 3 : 3 : 1**

Which statements are correct?

1 A **phenotype** is all the characteristics of an organism that are expressed.

2 A **genotype** is the genetic constitution of an organism consisting of the alleles present for one or more genes.

3 A **phenotype** arise from the interaction of an individual's genotype and its environment.

4 A **genotype** is the sum total of all the genes and their different alleles in a population of organisms.

5 An individual's **genotype** is inherited from a single parent by asexual reproduction or from 2 parents via gametes?

1. 1 and 2
2. 1 and 3
3. 2, 4, and 5
4. 1, 2, 3, and 5

In rabbit, there are two alleles for fur colour, grey and white, and two alleles for fur length, short and long. Two pure-breeding rabbits were mated, and the F_1 offspring all had grey and long hair. When the F_1 offspring were selfed, they produced the following numbers of F_2 offspring:

grey and long haired	92
grey and short haired	32
white and long haired	28
white and short haired	13

Which of the following are true?

1 The genes for fur colour and fur length assort independently.

2 The probability of producing pure-bred offspring is 1 in 16.

3 The original pure-breeding parents must be only grey and long haired, and white and short haired.

Skin colour in a variety of pumpkins is controlled by 2 pairs of alleles, Pp and Rr, which segregate independently.

The allele P is dominant and must be present for the development of pigmentation in the skin. Pumpkins without pigment are white.

Allele R is dominant and produces a red pigment in the skin. The recessive allele r gives a yellow colour.

In a test cross with a parent of unknown genotype, a phenotypic ratio of 1 red: 1 white was obtained.

What was the genotype of the unknown parent?

1. PPRR
2. PpRR
3. PPRr
4. Pprr

What I learnt …

01

- 2(o)
  Use genetic diagrams to solve problems involving test crosses