

GENETICS

20 FEBRUARY 2013

Lesson Description

In this lesson, we:

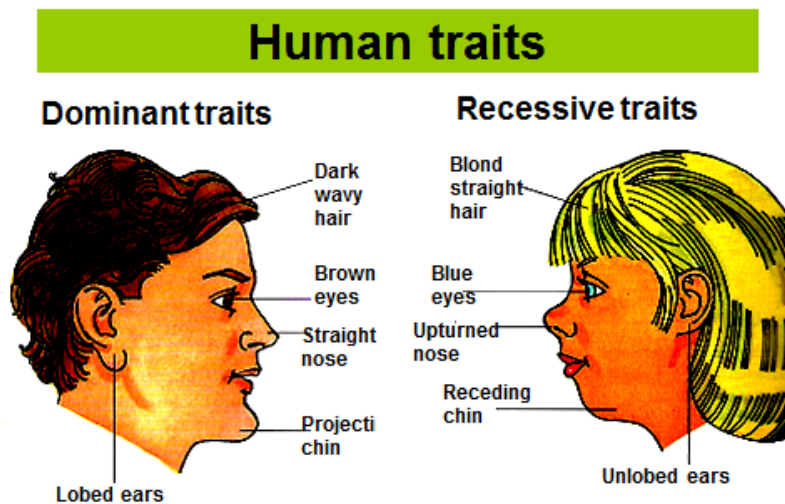
- Look at the definition of genetics.
- Discuss Mendel's concept of dominance & the law of segregation.
- Cover terminology of the genetic concepts.
- Look at genetics problems - complete, incomplete and co-dominance, blood groups.

Key Concepts

What is Genetics?

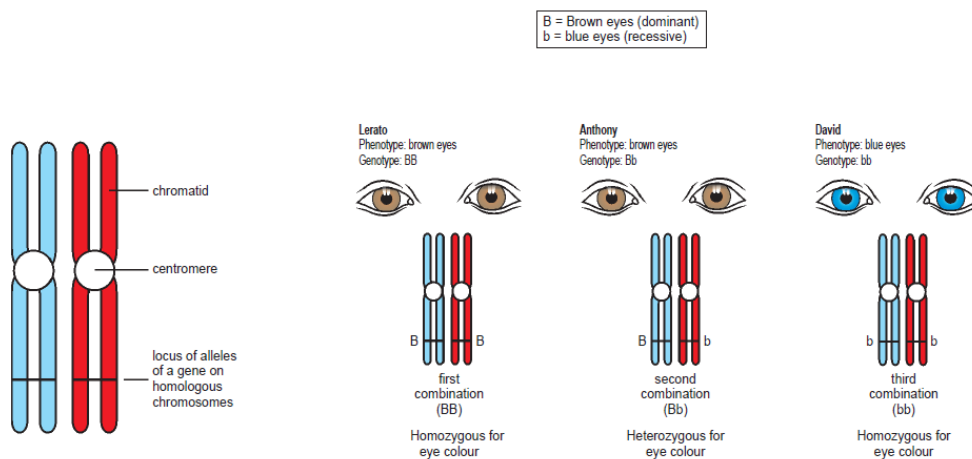
Genetics is the study of inheritance of characteristics

Some Characteristics in Humans



Terminology

Allele



(Life Sciences for all, Grade 12, MACMILLAN, Pg 247, Figure 5.21)

Homozygous and heterozygous

Genotype and phenotype

Dominant and recessive

Characteristic	Dominant traits	Recessive traits
eye colour	brown	blue
hair colour	dark hair	blonde hair
hairline	widow's peak	smooth hairline
lips	thick	thin
ears	earlobes free-hanging	earlobes attached
tongue	can roll tongue	cannot roll tongue

(Life Sciences for all, Grade 12, MACMILLAN, Pg 248)

Gregor Mendel - "Father of Genetics"



Austrian Monk.

Experimented with "pea plants".

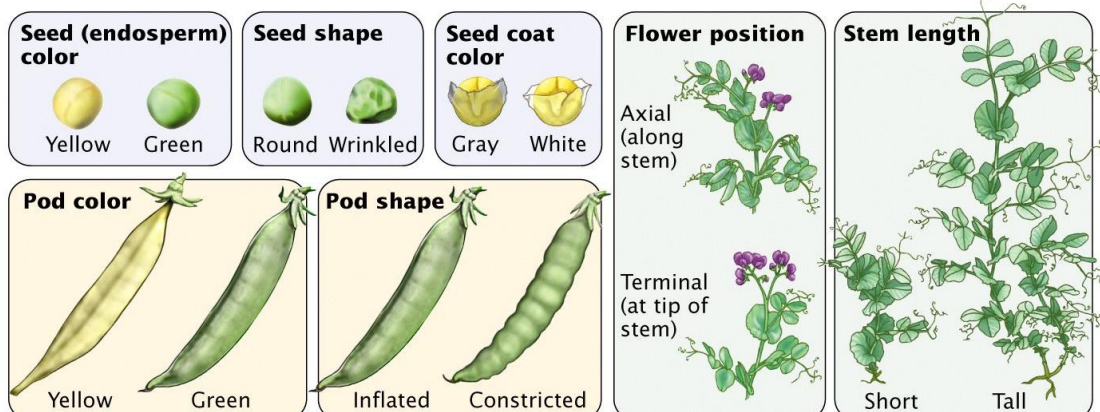
Understood that there was something that carried traits from one generation to the next- "FACTOR".

Worked with more than 28 000 plants. Why do scientists use such big samples?

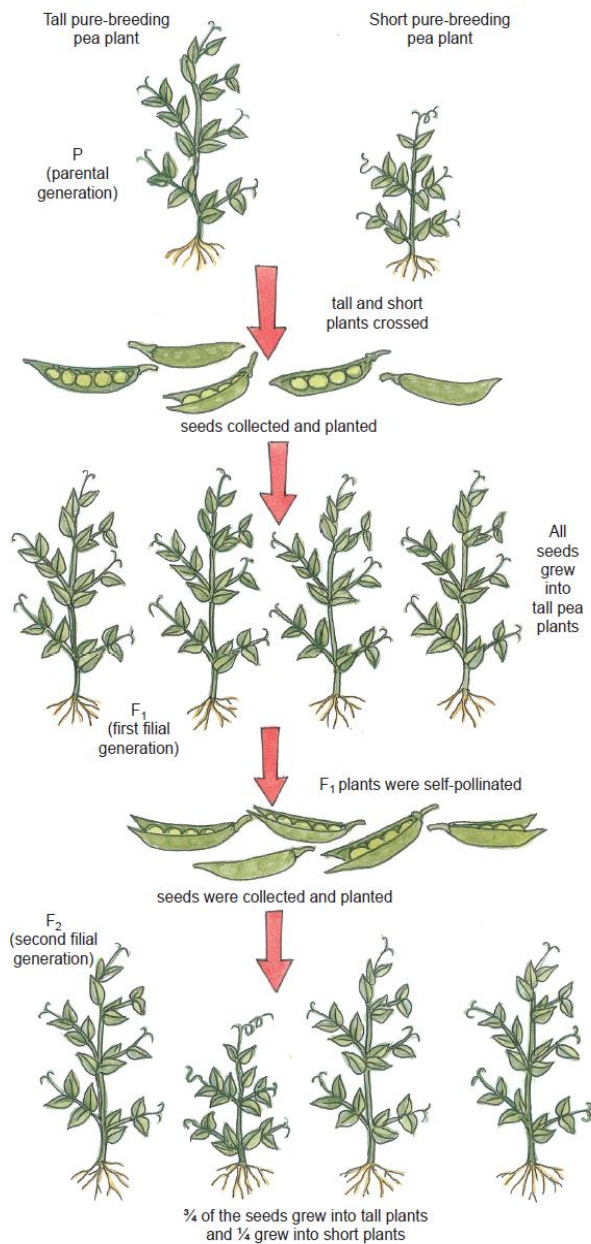
Why did he choose pea plants?

- Easy to cultivate
- Lots of progeny
- Pure-breeding strains are available
- They showed obvious differences in the traits
- Parentage can be controlled - Peas are self-fertilizing and can be crossed artificially

Mendel's Seven Characteristics



Monohybrid Crosses



Let T represent the allele for tall plants
Let t represent the allele for short plants

P (parental generation)

Phenotype
Genotype

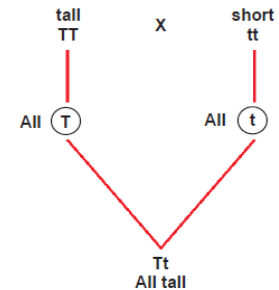
meiosis

Gametes

fertilisation

F₁ (first filial generation)

Genotype
Phenotype



Self fertilisations of F₁ pea plants

F₁

Phenotype
Genotype

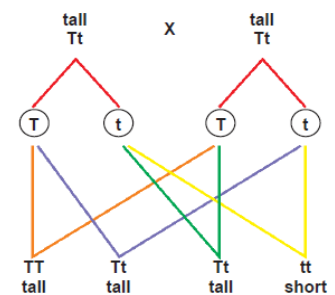
meiosis

Gametes

fertilisation

F₂ (second filial generation)

Genotypes
Phenotypes



This cross can also be written as a Punnett square

		Gametes of the other parent	
		T	t
Gametes of one parent	T	TT	Tt
	t	Tt	tt

Genotypic ratio = 1TT : 2Tt : 1tt
Phenotypic ratio = 3 tall : 1 short

A Punnett square can be used to predict the result of a genetic cross. It shows all the possible ways in which two types of alleles can combine to form the offspring, and all the possible genotypes of the offspring.

(Life Sciences for all, Grade 12, MACMILLAN, Pg 251, Figure 5.24 & 5.25)

By carrying out these monohybrid crosses, Mendel determined that the 2 alleles for each character segregate during gamete production. He thus formulated the **Law of Segregation**. Modern interpretation of the Law of Segregation: 'The characteristics of an organism are controlled by pairs of alleles which separate into different gametes as a result of meiosis. Therefore only one allele from each gene pair is present in a gamete.'

- The above example illustrates **COMPLETE DOMINANCE** - When two individuals with pure breeding (homozygous) contrasting characteristics are crossed, the F₁ generation all display the dominant characteristic.

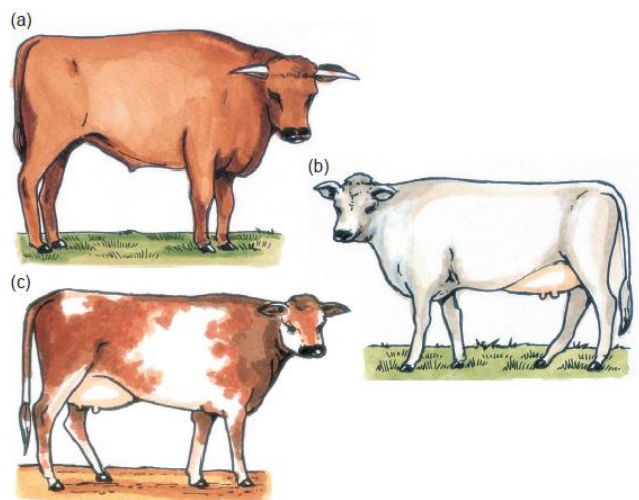
Not all characteristics follow in this pattern:

- Some show **INCOMPLETE DOMINANCE** - Neither allele is completely dominant over the other.



(Snapdragons showing incomplete dominance)

- Others display **CO-DOMINANCE** where genes have alleles that are **both expressed** in the heterozygote individuals



(Cows showing co-dominance)

Multiple Alleles

Blood Type

Human blood type is governed by the presence of 3 different alleles:

- A
- B
- O

However, each person only has 2 of these 3 alleles in their DNA

Blood types follow both Co-dominant and simple Dominant inheritance

- The A allele and B allele are **co-dominant** with each other
- The A allele and B allele are both purely **dominant** over the O allele
- The O allele is recessive

Blood Type	Genotype	Antigen	Antibody	Can receive blood from
A	$I^A I^A / I^A i$	A	B	A or o
B	$I^B I^B / I^B i$	B	A	B or o
AB	$I^A I^B$	A & B	None	All
o	ii	None	A & B	o

Example:

Show the cross between a mother who has type O blood and a father who has type AB blood.

Polygenic Traits

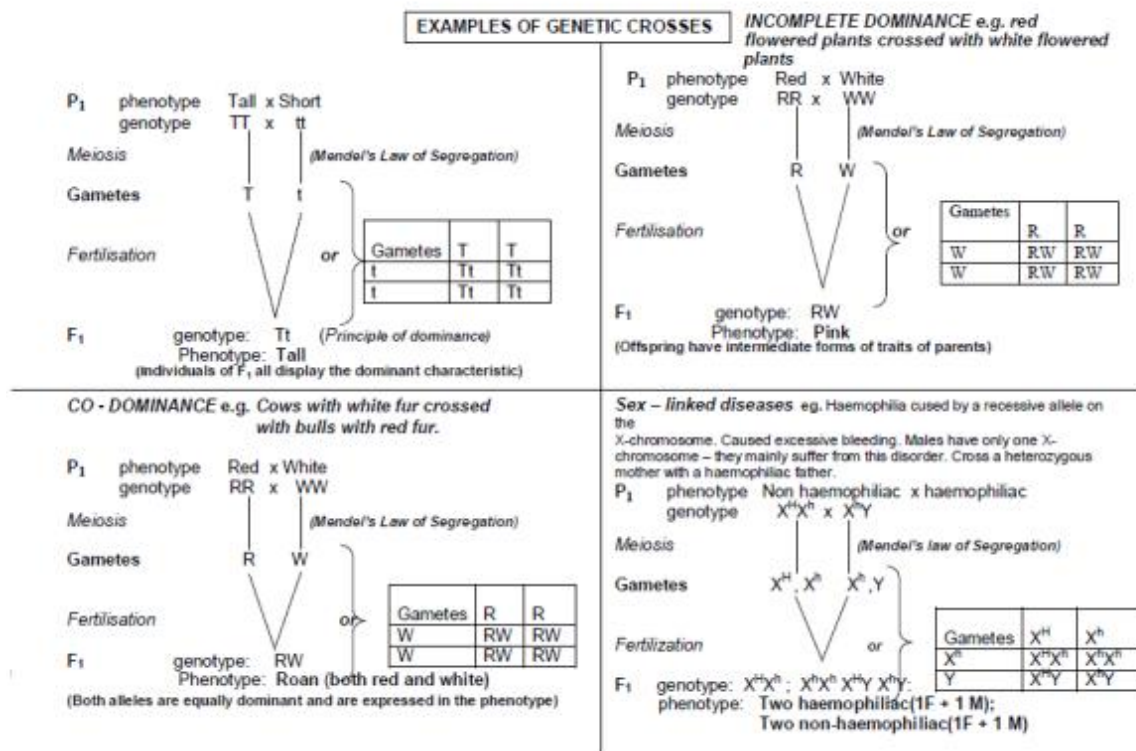
- Individual heritable characters are often found to be controlled by groups of several genes, called polygenes.
- Each allele intensifies or diminishes the a particular trait in the phenotype, i.e. it adds to the phenotype
- Variation is continuous or quantitative (adding up) - also called quantitative inheritance
- Seed Colour in wheat - aabbcc, Aabbcc, AaBbcc, AaBbCc, AABbCc, AABBCC (light, intermediate colours, dark)
- In humans - hair colour, height, skin colour

Testcross

A testcross is designed to reveal whether an organism that displays the dominant phenotype is homozygous or heterozygous.

Format for Genetic Crosses

(Use this whenever you have to solve a genetic problem)



(From Learner Resource)

Questions

Question 1

Give the correct biological term for the following:

- Different forms of a gene located at the same position on homologous chromosomes
- The appearance of an organism due to its genetic make-up
- An organism with unlike alleles for a particular characteristic
- An allele that expresses itself in the phenotype
- The genetic make-up of an organism.

Question 2

The table below shows the results obtained by first crossing a pure-bred black furred mouse with a brown furred mouse. The gene for black fur is dominant over the gene for brown fur. The F₁ generation was used as parents (consisting of 4 breeding pairs) of the F₂ generation.

	Number of black mice	Number of brown mice
Parents	1	1
F ₁ generation	8	0
F ₂ generation		
Offspring of 1 st breeding pair	8	0
Offspring of 2 nd breeding pair	7	1
Offspring of 3 rd breeding pair	5	3
Offspring of 4 th breeding pair	4	4

- From the data, calculate the phenotypic ratio of the mice with black fur and the mice with brown fur in the F₂ generation. Show ALL your workings.
- Suggest why it is better to use the four sets of offspring to calculate the ratio rather than using only one set.
- Draw bar graphs on the same system of axes to represent the phenotypic results in the F₂ generation offspring of each breeding pair shown in the table above.

Question 3

Hannes breeds a particular type of dog that has pointed ears. In these dogs, pointed ears (D) are dominant to drooping ears (d) which are recessive. Hannes wants to sell the pointed-eared dogs, but he has to make certain that the dogs are homozygous for pointed ears and do not have the droop-eared gene. In pointed eared dogs, homozygous and heterozygous dogs both look alike.

- How can Hannes tell which of the dogs are homozygous for pointed ears and which are heterozygous? What will he have to do to find out?
- Use diagrams to explain your answer.

Question 4

In a particular type of plant, the allele for red is incompletely dominant to that for white.

What is the genotype of two plants that are cross-pollinated to produce offspring that have only pink or white flowers? Use R to represent the red allele and W to represent the white allele.

Question 5

In an experiment to show co-dominance, cows with white fur (W) were crossed with bulls with red fur (R). All the offspring of the F₁-generation have roan fur (RW). A roan fur consists of patches of white and patches of red fur. Roan cows and roan bulls were crossed and the results are given below.

Genotype	RR	RW	WW
Number of Offspring	120	240	120

Give the ratio of the different phenotypes shown in the above table. Use the information in the table above to draw a pie-chart showing the proportions of the different genotypes.

Explain why the cows and bulls with genotype RW have roan fur and not only red or only white fur.

Question 6

In a maternity ward of a hospital two newly born babies were mixed up. One baby was blood type O and the other was blood type A. Both mothers thought that the baby with blood type O belonged to them. It was established that one of the babies' mothers was blood type AB and the other mother was blood type A.

- a.) What is meant by the terms (i) multiple alleles and (ii) co-dominant?
- b.) Which of these mothers gave birth to the baby with blood type O? Explain your answer.