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SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP) 2016



GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

SUBJECT: LIFE SCIENCES

SESSION 5

LEARNER NOTES

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GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA



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SESSION NO: 5

TOPIC: GENETICS AND INHERITANCE PART 1

Note to Learner:

- You **MUST** understand the link between meiosis and genetics. During the crossing over in prophase I of meiosis, chromosomes share information and then during metaphase I, separate randomly.
- This determines the combination of chromosomes and genes that you have as an individual. Genetics determines individual variation (to be different) and survival of the fittest.
- They **MUST** have a clear understanding of the genetic terminology in order to study genetics and answer genetic problems.
- Mendel's Laws are very important - understand the concepts of dominance and how this plays a role in monohybrid crosses (mono = one = one characteristic or trait).
- Be aware of confusing the word 'cross/ crossing' with 'crossing over' in Meiosis. You cross individuals and calculate the chances of a characteristic or trait being in the offspring. You must be clear of the difference between these two terms.
- Questions on blood group inheritance and sex determination are often asked. The more examples of genetic crosses that you do, the better you will do.
- Pedigree diagrams are a popular way to express family history and are often asked in exams. Make sure you know how to answer them.
- There are basically **FOUR types crosses e.g.** $HH \times hh$;
 $Hh \times Hh$;
 $Hh \times hh$;
 $Hh \times HH$
- In the notation of the genotype the dominant allele represented by a **CAPITAL LETTER** must always be written first e.g. Gg and **NOT** gG



SECTION A: TYPICAL EXAM QUESTIONS**QUESTION 1: Multichoice 7 minutes** (Taken from various sources)

(Note: When answering multi-choice questions:

1. Read the question while covering the answers.
2. Think of the correct answer.
3. Look for your answer.
4. Write the letter down on your answer book.

BUT: If you do not know the answer after point 1 and 2, then:

3. Look at the options. Eliminate those that incompletely incorrect.
4. Choose between the remaining options.

(Reminder: there are only 4 basic types of crosses. Make sure you are able to use them properly. Do a quick cross in pencil, next to the relevant question to find the correct answer)

Various options are given as possible answers to the following questions. Choose the correct answer and write only the LETTER (A-D) next to the question number (1.1.-1.7) in your ANSWER BOOK, e.g. 1.8. D

1. The term for the physical appearance of an organism due to the genetic composition:
A heterozygous
B genotype
C homozygous
D phenotype
2. When the alleles of genes on homologous chromosomes differ, the organism is
A homozygous
B dominant
C heterozygous
D recessive
3. The genotype of a plant that results from a cross between a plant with red flowers (RR) and white flowers (rr) will be:
A RR
B Rr
C rr
D rR



4. Choose the correct cross if the result is 50% homozygous dominant and 50% heterozygous in the F_1 generation:
- A Bb x bb
 - B BB x Bb
 - C BB x bb
 - D Bb x Bb
5. Two white heterozygous cats were crossed where white fur is dominant over black fur. Choose the correct phenotype of the F_1 generation:
- A 25% white and 75% black
 - B 50% black and 50% white
 - C 25% black and 75% white
 - D 100% white
6. A heterozygous red flower plant was crossed with a homozygous white flower plant and yielded 300 new plants. What number of the new plants will carry white flowers?
- A 150
 - B 225
 - C 300
 - D 196
7. The babies of a purebred white rabbit were crossed with a purebred black rabbit. Black hair dominates over white hair. The offspring of the F_2 will be:
- A all black
 - B all white
 - C 75% black and 25% white
 - D 75% white and 25% black
- (7 x 2) [14]

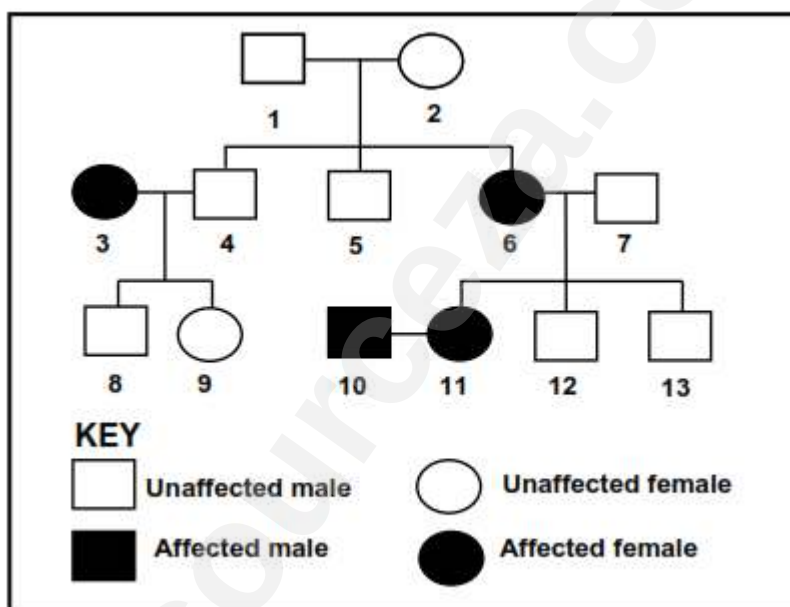


QUESTION 2: 8 minutes (Taken from DoE November 2008 Paper 1)

(The following question is based on a pedigree diagram. Please see the content summary for hints to answer questions on pedigree diagram. In this diagram, the family history is shown as a schematic diagram. Always identify the recessive individuals first. Write their trait symbols next to the number e.g.: S = straight hair and s = wavy hair. So ss = homozygous for the recessive trait)

A genetic disorder, phenylketonuria (PKU), is caused by a recessive allele (n).

An individual with the disorder is described as affected and an individual without it is described as unaffected. The pedigree diagram below illustrates inheritance of this disorder in a family.



- 2.1 Give the possible genotype(s) of individual 4. (2)
- 2.2 How many individuals in the second generation (individuals 3 to 7) are homozygous recessive? (1)
- 2.3 Give the NUMBER only of any TWO individuals in the third generation (individuals 8 to 13) that are heterozygous. (2)
- 2.4 Using information from the pedigree diagram above, explain why the allele for PKU cannot be sex-linked. (3)
- (8)**

QUESTION 3: 8 minutes (Taken from DoE November 2009 Paper 1)

Fur colour in mice is controlled by a gene with two alleles. A homozygous mouse with black fur was crossed with a homozygous mouse with brown fur. All the offspring had black fur.

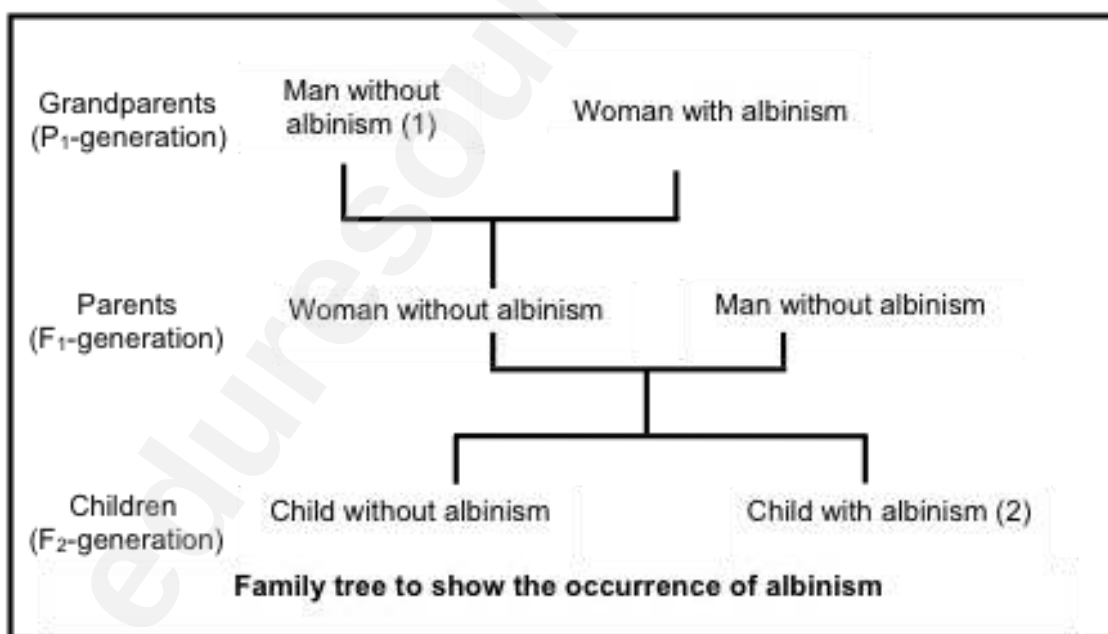
Using the symbols B and b to represent the two alleles for fur colour, show as a Punnet square, a genetic cross between a mouse that is heterozygous for fur colour with a mouse with brown fur. Show the possible genotypes and phenotypes of the offspring. (6)

(Remember to include P_1 and F_1 , as well as genotype and phenotype, ratios and % in your work.)

QUESTION 4: 5 Minutes (Taken from DoE November 2008 Paper 1)

People with albinism are unable to produce the dark pigment, melanin, in their skin. This condition is caused when an individual is homozygous recessive for this characteristic. The family tree below shows the occurrence of albinism over three generations.

(This is a pedigree diagram. Always first mark the homozygous recessive individuals on the diagram before trying to work out the genetic traits for the other individuals. Albinism is homozygous recessive, so an individual with albinism will be 'aa' and a person who is not an albino will be either 'AA' or 'Aa'.)



4.1. Indicate whether each of the individuals below could be homozygous dominant, homozygous recessive or heterozygous:

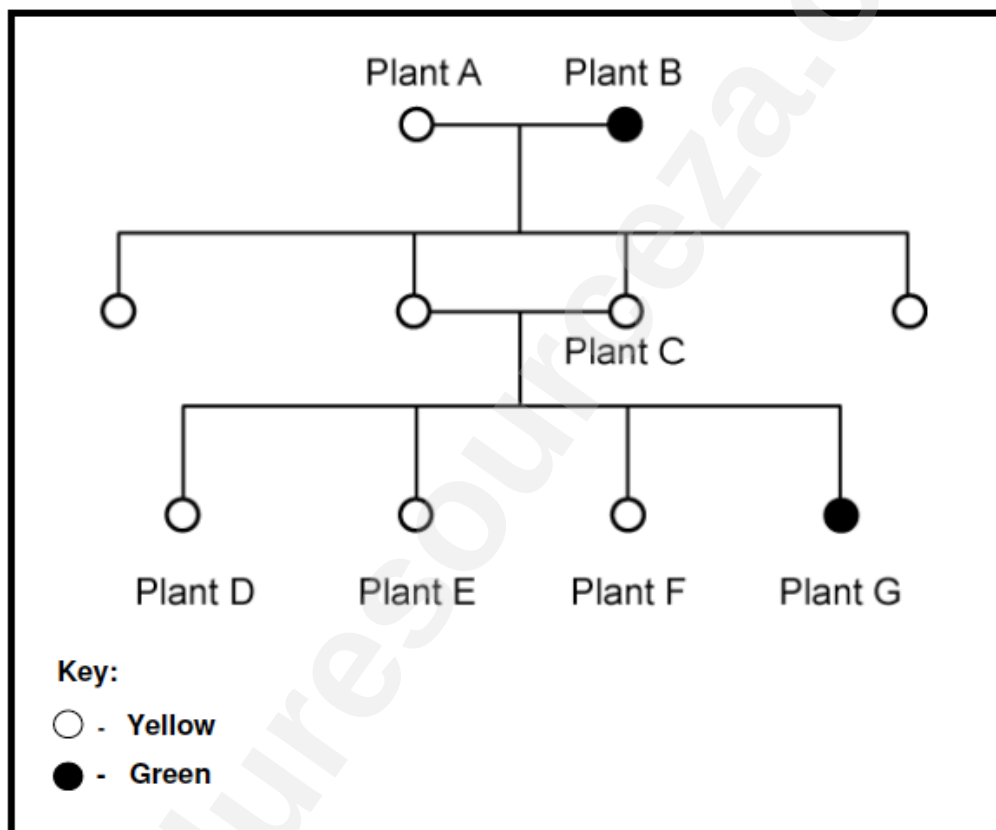
- (a) 1 (2)
(b) 2 (1)

4.2. Explain your answer to QUESTION 4.1 (a). (2)

QUESTION 5: 6 minutes*(Taken from Free State Prelim 2009)***[5]**

Sello crosses two pure breeding garden pea plants in the laboratory. Plant A produces yellow peas and plant B green peas. He knows that the gene, for yellow peas (Y), is dominant over the gene for green peas (y). The diagram below shows the results he obtained for two generations of pea plants. Study the diagram and answer the questions that follow:

(Reminder: yellow is dominant and green is recessive. For a pea plant to yield green peas, this plant must be 'yy' – so homozygous recessive. Also refer to Mendel's law of dominance and segregation in the content summary.)



- 5.1. Give the genotype for plant A and plant B. (2)
- 5.2. Provide the phenotypic ratios for the F₂ generation. (2)
- 5.3. If Sello allows plant G to self-pollinate, give the phenotype and genotype of the offspring. (2)

[6]

QUESTION 6: 6 minutes (Taken and adapted from NSC November 2015 Paper 2)

A man and a woman both have blood group **B**.

Use a genetic cross to show how it is possible for them to have a child with blood group **O**.

[6]

(Remember that in blood groups there are three alleles A, B and O. A and B are co-dominant over O which is recessive. There must be two of the same alleles if a recessive trait is present in the individual)

QUESTION 7: 12 minutes (Taken from DoE Nov 2011 Paper 1)

Haemophilia is a sex-linked disease caused by the presence of a recessive allele (X^h). A normal father and heterozygous mother have children.

(Remember: X^H is dominant and normal. X^h will carry the recessive haemophilia gene)

- 7.1. Represent a genetic cross to determine the possible genotypes and phenotypes of the children of these parents. (6)
 - 7.2. What are the chances of the parents having a child that will be a haemophiliac male? (2)
 - 7.3. Explain why the father is not a carrier for haemophilia. (2)
- [10]



SECTION B: NOTES ON CONTENT**GENETICS AND HEREDITY**

Genetics is the **science of inheritance** and studies the principles of heredity and variation. The hereditary instruction carried within the DNA ensures that offspring resemble their parents and ensures that **genetic variation** can take place, resulting in survival of the fittest.

Genetics and sexual reproduction:

During sexual reproduction, offspring are produced that resemble the parents. Remember that **two haploid** gametes are the result of the process of **meiosis**. The gametes fuse during reproduction and the result is a **diploid zygote**, containing a double set of chromosomes. One set of the chromosomes came from the male gamete, which contains the DNA from the father. One set of chromosomes came from the female gamete and contains the DNA from the mother. The child therefore contains DNA from both parents.

DEFINITIONS AND IMPORTANT TERMS AND CONCEPTS:

- **Chromatin network:** visible as thread-like structures in the nucleus of an inactive cell
- **Chromosome:** a structure made up of two chromatids joined by a centromere that carries the hereditary characteristics within the DNA.
- **Gene:** the hereditary unit of DNA that occupies a specific location on a chromosome and controls the development of the characteristics
- **Allele:** one of two contrasting genes that determine alternative characteristics in inheritance because they are situated in the same position or locus on homologous chromosomes
- **Locus:** The exact position or **location** of a gene on a chromosome.
- **Genotype:** This is the total **genetic composition** of an organism. It is the information present in the gene alleles, for example BB, Bb or bb.
- **Phenotype:** This is the external, **physical appearance** of an organism. The phenotype is determined by the genotype.
- **Dominant allele:** an allele that masks or suppresses the expression of the allele partner on the chromosome pair and the dominant characteristic is seen in the homozygous (e.g: TT) and heterozygous state (e.g: Tt) in the phenotype.
- **Recessive allele:** an allele that is suppressed when the allele partner is dominant. The recessive trait will only be expressed/seen if both alleles for the trait are homozygous recessive e.g: tt
- **Homozygous:**(true-breeding) when two alleles that control a single trait(on the same locus) are **identical**.



- **Heterozygous:**(hybrid) when two alleles that control are **different** for a single trait(on the same locus) are **different** .
- **Gene mutation:** a change of one or more N-bases in the nuclear DNA of an organism. If the mutation is favourable, the organism survives but should the mutation be unfavourable, the organism will die.
- **Chromosomal aberrations:** refers to changes in the normal structure or number of chromosomes.
- **Genetic variation:**this includes a variety of different genes that may differ from maternal and paternal genes resulting in new genotypes and phenotypes.
- Multiple alleles: when there are more than two possible alleles for one gene locus.
- Multiple alleles: when there are more than two possible alleles for one gene locus. E.g. blood groups
- **Complete dominance:** The genetic cross where the dominant allele masks(blocks) the expression of a recessive allele in the heterozygous condition.
- **Incomplete/partial dominance:** A genetic cross between phenotypically different parents produces offspring different from both parents but with an intermediate phenotype.

Examples:

Incomplete dominance in flowers:

Colour key: **R** (red) **W** (white)

P₁ **Phenotype:** red x white
 Genotype: RR x WW
 Meiosis
 Gametes R R x W W

Fertilisation

F₁ **Genotype:** 4:4 RW
 Phenotype: 100% pink

Example:

Incomplete dominance in humans:

Curly (**CC**) plus Straight SS = Wavy (**CS**)



- **Co-dominance:** a genetic cross in which both alleles are expressed equally in the phenotype.

E.g. Parent with blood group A mates with parent with blood group B and can produce an offspring with blood AB

Phenotype/Blood type	Genotype	Can receive blood from:
A	$I^A I^A$	A or O
A	$I^A i$	
B	$I^B I^B$	B or O
B	$I^B i$	
AB	$I^A I^B$	A, B, AB or O (also known as the universal acceptor because blood group AB can <u>accept</u> blood from any other group)
O	ii	O (also known as the universal donor because any blood group can <u>receive</u> O blood)

Co-dominance in humans:

Homozygous dominant = $I^A I^A$ (blood group A)

Homozygous recessive = $I^B I^B$ (blood group B)

Heterozygous = $I^A I^B$ (blood group AB)

Co-dominance in flowers:

Homozygous dominant = **RR** (red)

Homozygous dominant = **WW** (white)

Heterozygous = **RW** (white with red markings/red with white markings)

- **Monohybrid cross:** when **one pair** of traits (colour trait) is crossed to determine the possible inheritance in the offspring. There will always be **4** possible combinations e.g. colour trait
- **Dihybrid cross:** the crossing of **two pairs** of contrasting traits (colour trait and height) to determine the possible inheritance of the offspring. There will be 16 possible combinations.



- **Filial generation:** The first generation of parents (P_1) will produce **offspring** that result from a cross called the **first filial generation** (F_1). The interbreeding of the offspring will produce F_2 (**second filial generation**)

EXAMPLES OF MONOHYBRID CROSSES:

There are basically **FOUR types of crosses**.

We will use one general trait e.g. hair colour:

B = brown hair colour (dominant trait)

b = blonde hair colour (recessive trait)

CROSS EXAMPLE 1: (Homozygous dominant x homozygous recessive) [OFTEN ASKED]

P_1 (first parent generation)

Phenotype: Brown x blonde

Genotype: BB x bb

Meiosis

Gametes: B B x b b

Fertilization

	B	B
B	Bb	Bb
B	Bb	Bb

F_1 (first filial generation = first offspring)

Genotype: Bb

Phenotype: 100% brown



CROSS EXAMPLE 2: (Heterozygous x Heterozygous)

P₁ **Phenotype:** Brown x Brown
 Genotype: Bb x Bb
 Meiosis
 Gametes: B b x B b
 Fertilization

	B	B
B	BB	Bb
B	Bb	Bb

F₁ Genotype: BB: Bb Bb : bb
 1 : 2 : 1
Phenotype: 75% brown and 25% blonde
 3 : 1

CROSS EXAMPLE 3: (Homozygous dominant x Heterozygous)

P₁ **Phenotype:** Brown x Brown
 Genotype: BB x Bb
 Meiosis
 Gametes: B, B x B, b
 Fertilization

	B	B
B	BB	BB
b	Bb	Bb

F₁ Genotype: BB BB: Bb Bb
 1 : 1
Phenotype: 100% brown

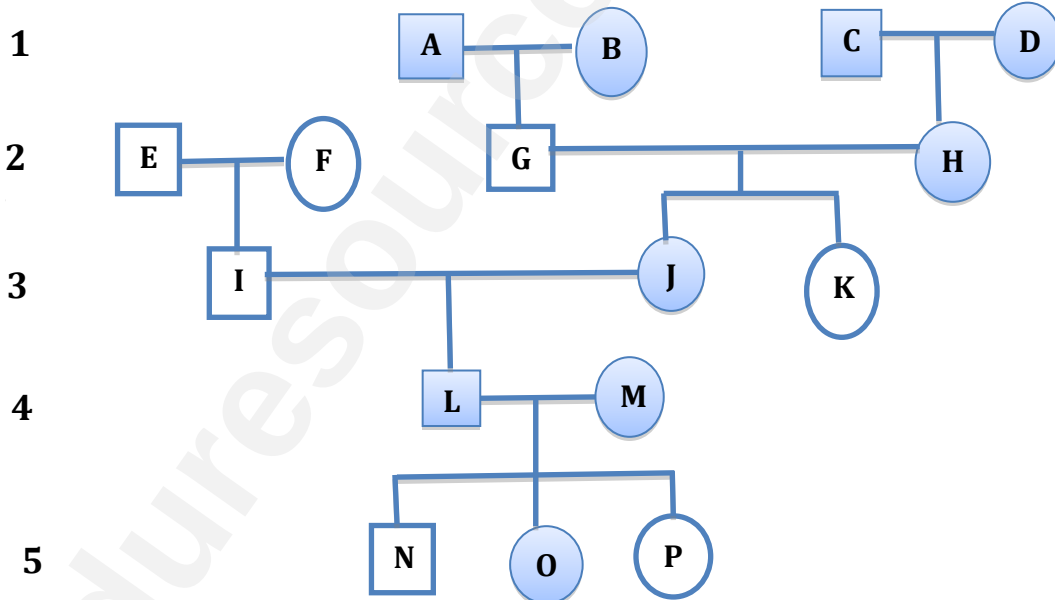


CROSS EXAMPLE 4: (Homozygous recessive x Heterozygous)

P₁ **Phenotype:** Blonde x Brown
 Genotype: bb x Bb
 Meiosis
 Gametes: b b x B b
 Fertilisation

	b	B
B	Bb	Bb
b	bb	Bb

F₁ **Genotype:** Bb Bb : bb bb
 1 : 1
 Phenotype: 50% brown and 50% blonde
 1 : 1

HOW TO TACKLE ANSWERING PEDIGREE DIAGRAM QUESTIONS**Generation**

-  Female with blonde hair
-  Male with blonde
-  Female with brown
-  Male with brown

Analysing the genetic lineage in a pedigree diagram:

- Step 1:** Mark all the **homozygous recessive** individuals with blonde hair. This will be all the white shapes: E, F, G, I, K, N and P as **bb** on the pedigree chart.
- Step 2:** Work from the generation line 5 up towards the generation line 1 so that you start with the last offspring on the pedigree diagram. To produce an offspring with **bb**, BOTH parents must have at least one homozygous recessive gene (**b**). If the parent is a white shape – then the parent is **bb** and already marked. If the parent is a shaded shape and produced a **bb** offspring, then the parent must be heterozygous **Bb**. Mark the **Bb** parents on the pedigree diagram.
- Step 3:** Parents that are shaded shapes and produce only shaded shape offspring, can be homozygous **BB** or heterozygous **Bb**. Look to the next generation and then work backwards. Mark the parents on the pedigree diagram.
- Step 4:** Answer the questions that relate to the pedigree diagram.

Try to work out the genotype of A, B, C, D, H, J, L, M and O on your own first.

Let us see if you were right:

- A and B are **Bb** because they produce G (**bb**)
 - If C is **BB** then D must be **Bb** or C is **Bb** then D is **BB** because H must be **Bb** to produce K (**bb**)
 - J is **Bb** because G is **bb** and H is **Bb** (produced sister K - **bb**)
 - L and M are both **Bb** because parent J is **Bb** and I is **bb** so they cannot be homozygous BB AND L and M produce a son (N) and daughter (P) that are both homozygous **bb**
 - Offspring O can be either **BB** or **Bb** because both parents are heterozygous **Bb**
- **Karyotype:** The number, shape and arrangement of all the chromosomes in a nucleus of a somatic cell.
 - **Sex determination in humans:** There are 22 pairs of autosomes and one pair of sex chromosomes (gonosomes) in the human karyotype.

Females **XX** sex chromosomes while males have dissimilar **XY** sex chromosome.

Each time fertilisation occurs, there is a 50% chance of the zygote being male and a 50% chance of the zygote being female, $X + X = XX$ and $X + Y = XY$.



	X	Y
X	XX	XY
X	XX	XY

- **Sex-linked alleles** characteristics or traits that are carried on the sex chromosomes.
- **Haemophilia:** A sex-linked condition where blood fails to clot properly. This recessive allele is found only on the X chromosome of the sex chromosomes.

A female will only be haemophilic if she has both homozygous recessive alleles.

EXAMPLES**1. For a normal male and female carrier (heterozygous) cross:****P₁ Phenotype:** normal male x female carrier**Genotype:** X^HY x X^HX^h **Meiosis****Gametes:** $X^H Y$ x $X^H X^h$ **Fertilization**

	X^H	Y
X^H	$X^H X^H$	$X^H Y$
X^h	$X^H X^h$	$X^h Y$

F₁ Genotype: $X^H X^H$ $X^H X^h$ $X^H Y$ $X^h Y$
 normal female: female carrier: normal male: haemophilic male
 25% : 25% : 25% : 25%

Phenotype: 50% normal females: 25% normal male: 25% haemophilic males**2. For an affected male and normal female cross:****P₁ Phenotype:** affected male x normal female**Genotype:** $X^h Y$ x $X^H X^H$ **Meiosis****Gametes:** $X^h Y$ x $X^H X^H$ **Fertilization**

	X^h	Y
X^H	$X^H X^h$	$X^H Y$
X^H	$X^H X^h$	$X^H Y$

F₁ Genotype: $X^H X^h$ $X^H X^h$ $X^H Y$ $X^H Y$ 50% of F₁ is female carriers : 50% of F₁ is normal males

1 : 1
Phenotype: 100% normal

The Principles of Heredity: (Make sure that you know Mendel's laws)

- **Mendel's Principle of Segregation:** During gametogenesis the two alleles of a gene separate so that each gamete will receive one allele of a gene for a specific characteristic.

- **Mendel's law of Dominance**

When two individuals with contrasting pure breed characteristics are crossed, the individuals of the first generation (F_1) will **ALL** resemble the parent with the dominant characteristic.

P₁ **Phenotype:** Tall plants x short plants
Genotype: $TT \times tt$
Meiosis
Gametes: $T, T \times t, t$ (principle of segregation)
Fertilization

	T	T
t	Tt	Tt
t	Tt	Tt

F₁

Genotype: 100% Tt (heterozygous tall)

Phenotype: 100% Tall (Law of Dominance)

Note: that the F_1 offspring have characteristics from both parents but in the phenotype, all display the dominant characteristic.

The offspring of the F_1 (Tt) grow and mature to become P_2 . The offspring of P_2 are known as F_2 .

P₂ **Phenotype:** Tall plants x tall plants
Genotype: $Tt \times Tt$
Meiosis
Gametes: $T, t \times T, t$
Fertilization

	T	t
T	TT	Tt
t	Tt	tt

F₂

Genotype: 1 TT : 2 Tt : 1 tt
 Homozygous tall : heterozygous Tall : homozygous short
Phenotype: 75% tall : 25% short



- **Mendel's law of independent assortment**

Alleles of a gene for one characteristic segregate independently of the alleles of a gene of another characteristic. The alleles for the two different genes will therefore come together randomly during gamete formation. This is also known as random assortment.

- **Mutations (also refer to the note sets on DNA Sessions 1-4))**

A gene mutation is a **change** in the genetic material/DNA sequencing in the cell.

EFFECTS OF MUTATIONS

Mutations assist the organism to **adapt** to its environment.

- **HARMFUL MUTATIONS:** causes changes in DNA that can cause errors in protein sequencing, that can result in partially or non-functional proteins.
- **HARMLESS MUTATIONS:** have no effect on the structure or functioning of the organisms.
- **USEFUL MUTATIONS:** can be advantageous to the organism and they are passed on from parent to offspring.

Albinism as an example of a mutation:

Albinism is the absence of the protein that forms the pigment **melanin** in the skin, hair and eyes .

Albinism is an **AUTOSOMAL** disorder caused by a **single pair of recessive alleles** and will only show in the **homozygous** state.

EXAMPLES

1. When one parent is affected and one is normal:

P₁	Phenotype:	Affected parent	x	Normal parent
	Genotype:	gg	x	GG
	Meiosis			
	Gametes:	g , g	x	G , G
	Fertilization			

	g	g
G	Gg	Gg
G	Gg	Gg

F₁ **Genotype:** Gg (100% heterozygous normal carriers)
Phenotype: 100% normal



2. When both parents are heterozygous carriers:

P₁ **Phenotype:** normal heterozygous parent x normal heterozygous parent
Genotype: Gg x Gg
Meiosis
Gametes: G , g x G , g
Fertilization

	G	g
G	GG	Gg
g	Gg	gg

F₁ **Genotype:** 1 GG : 2 Gg : 1 gg
 1 homozygous normal : 2 carriers : 1 albino

Phenotype: 75% normal : 25% albinos (affected)
 3 : 1

- **Genetic Engineering:** the process where scientists alter, swap or manipulate the genes on the DNA, to produce an organism with desirable characteristics.

Advantages of Genetic engineering	Disadvantages of Genetic engineering
• Production of medication/resources cheaply. • Control pests with specific genes inserted into a crop. • Uses specific genes to increase crop yields/food security. • Selecting genes to increase shelf-life of plant products	• Expensive/research money could be used for other needs. therefore • Interfering with nature or immoral. • Potential health impacts. • Unsure of long-term effects.

Cloning

Process by which genetically identical organisms are formed using biotechnology.

- With cloning, the nucleus of a **somatic** cell (2n) of one organism is removed.
- An ovum (n) is taken from an ovary of another organism.
- The nucleus of the ovum is destroyed.
- The somatic cell's nucleus (2n) is then placed inside the ovum.
- The ovum is put back into a uterus where it is allowed to grow and differentiate into an embryo.
- When the new offspring is produced, it is identical to the original organism.
- A sheep called Dolly was cloned successfully in 1997.



Stem Cell research:

A stem cell is any cell in the body that can differentiate into specialised tissue in the body.

SOURCES OF STEM CELLS

Stem cells can be harvested from:

- umbilical cord blood (once a baby has been born),
- a foetal blastocyst and
- bone marrow.

USES OF STEM CELL THERAPY

To treat:

- cancers like Leukemia
- degenerative diseases like Multiple Sclerosis
- diabetes mellitus where the pancreas no longer produces insulin
- muscle damage
- organ damage and
- certain genetic diseases in conjunction with gene therapy



SECTION C: HOMEWORK QUESTIONS

(Questions for homework taken from DoE Additional Exemplar 2008 Paper 1, and Gauteng Prelim 2009 Paper 1, DbE November 2015 P2, DbE November (2) 2015 P2))

QUESTION 1: 8 minutes

In mice, brown (B) coat colour is dominant over grey (b) coat colour. Show a cross between a heterozygous parent with a brown coat colour and one with a grey coat colour up to the F₁ generation. Also give the phenotypes of the F₁ generation. (8)

QUESTION 2: 6 minutes

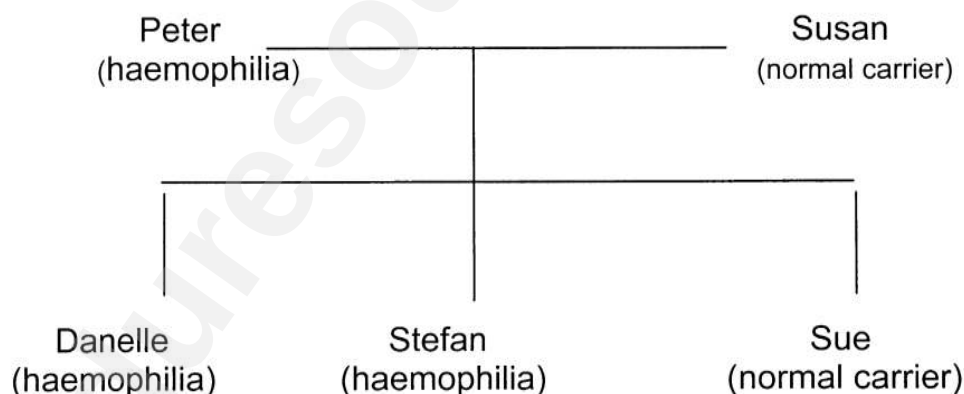
Learners want to investigate eye colour in fruit flies (*Drosophila melanogaster*). Fruit flies can have red (R) eyes or white (r) eyes. Red eye colour is dominant and white eye colour is recessive. Male fruit flies, homozygous for red eye colour, were bred with female fruit flies, homozygous for white eye colour.

Show how the possible phenotypes and the genotypes of the F₁ generation for eye colour may be obtained. (6)

QUESTION 3: 8 minutes

Haemophilia is a sex-linked hereditary disease that occurs as a result of a recessive allele on the X-chromosome. Study the family tree below and answer the questions that follow:

(Use the symbols **H** for normal and **h** for haemophilia above the sex chromosomes, for example: X^HX^h)



- 3.1. Write down the genotype of Stefan. (2)
- 3.2. Peter and Susan would like to have a fourth child. Calculate the percentage probability of this child having haemophilia. (6)

QUESTION 4 : 15 minutes

- 4 Learners conducted an investigation to determine to which blood group most learners in their school belong.

They recorded the blood groups of 120 learners from each grade. The results are shown in the table below.

GRADE	NUMBER OF LEARNERS IN EACH BLOOD GROUP			
	A	B	AB	O
8	20	30	16	54
9	36	24	28	32
10	35	5	15	65
11	50	20	15	35
12	24	26	28	42

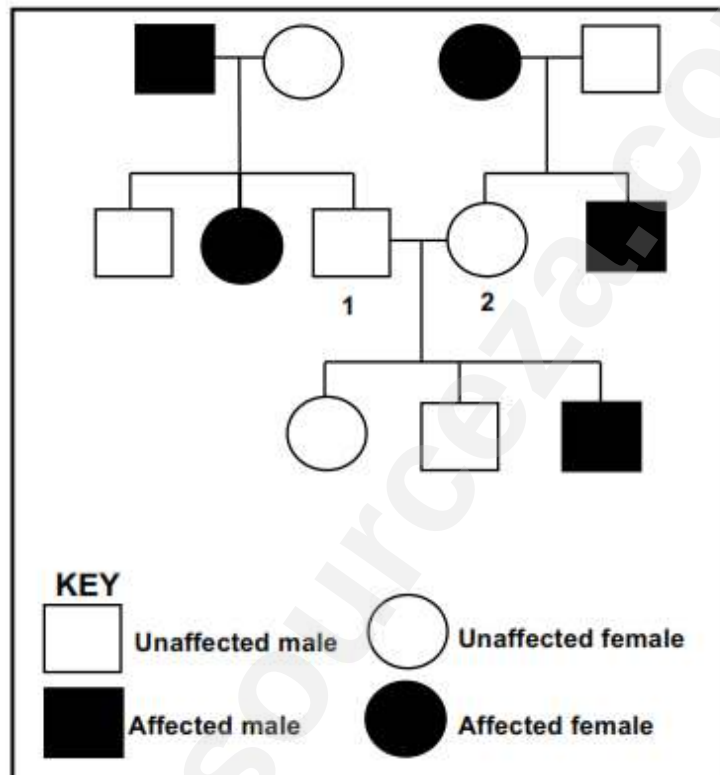
- 4.1 Formulate a hypothesis for this investigation. (2)
- 4.2 State TWO planning steps that should be considered before undertaking this investigation. (2)
- 4.3 Draw a bar graph, illustrating the blood group distribution of Grade 11 learners. (6)
- 4.4 Using the information from the table, write a suitable conclusion for this investigation. (2)
- 4.5 Explain why blood group **O** occurs normally more frequently in a population. (3)
- (15)**



QUESTION 5 : 9 minutes

A lack of immunity to infections (agammaglobulinemia) is a sex-linked recessive genetic disorder in humans. The dominant allele is represented by X^A and the recessive allele is represented by X^a .

An individual with the disorder is described as affected and an individual without it is described as unaffected. The pedigree diagram below illustrates inheritance of this disorder.



- 5.1. Name the genotypes of individuals:
- (a) 1 (2)
- (b) 2 (2)
- 5.2. What percentage of the males in this pedigree diagram is affected? Show ALL working. (2)
- 5.3. Explain why any son of an affected female will always have this disorder. (3)
- (9)