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GENETICS TERMS

Learner Note: You MUST understand the link between meiosis and genetics. During the crossing over in prophase I of meiosis and the metaphase I, chromosomes share information and the during metaphase, 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. You MUST have a clear understanding of the genetic terminology in order to study genetics and answer genetic problems. Pedigree charts are a popular way to express family history. In a pedigree chart, first establish which of the individuals are **homozygous recessive** for a gene combination, as this is always a surety and can be seen easily on the chart. There are basically **FOUR crosses**. If you know these crosses, you should not have a problem.

Let's use hair colour: B = brown hair colour (dominant hair colour) b = blonde hair colour (recessive)

CROSS EXAMPLE 1

P₁ BB x bb

gametes	B	B
b	Bb	Bb
b	Bb	Bb

F₁Genotype: 4:4 Bb heterozygous offspring (always include the ratios)

Phenotype: 100% brown (always include the %)

CROSS EXAMPLE 2:P₁

Bb x Bb

gametes	B	b
B	BB	Bb
b	Bb	bb

F₁Genotype: 1:4 BB homozygous offspring

2:4 Bb heterozygous offspring

1:4 bb homozygous

Phenotype: 75% brown and 25% blonde

CROSS EXAMPLE 3:**P₁****BB x Bb**

gametes	B	B
B	BB	BB
b	Bb	Bb

F₁Genotype: 2:4 BB homozygous offspring
 2:4 Bb heterozygous offspring

Phenotype: 100% brown

CROSS EXAMPLE 4:**P₁****bb x Bb**

gametes	b	b
B	Bb	Bb
b	bb	bb

F₁Genotype: 2:4 Bb heterozygous offspring
 2:4 bb homozygous offspring

Phenotype: 50% brown and 50% blonde

SECTION A: TYPICAL EXAM QUESTIONS - 35 minutes**QUESTION 1: Multichoice – 7 minutes**

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

- The term for the physical appearance of an organisms due to the genetic composition:
 - heterozygous
 - genotype
 - homozygous
 - phenotype

2. When the allele 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 crossed with a purebred black rabbit where crossed. 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

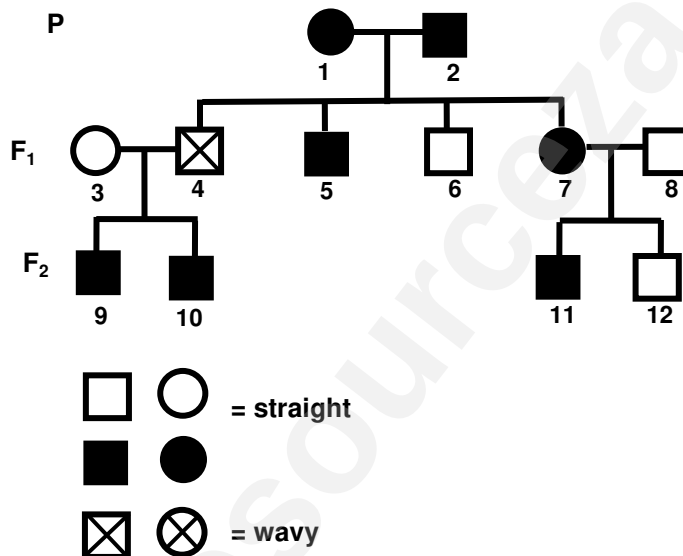
(7)

QUESTION 2: - 11 minutes

(The following question is based on a pedigree chart. In this chart, 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)

The eight items below are based on the pedigree diagram which shows the phenotypes of offspring from wavy-haired parents. Write down the letters A, B, C or D according to the following key:

- A - if the statement is TRUE
- B - if the statement is FALSE
- C - if there is a 25% chance that the statement is TRUE
- D - if there is a 50% chance that the statement is TRUE



- 2.1. Wavy hair is dominant.
- 2.2. Individual 1 is homozygous
- 2.3. If individual 6 married a woman with straight hair, all of the offspring would have straight hair.
- 2.4. Individual 4 is homozygous.
- 2.5. One of the parents of 2 had the same genotype as 2.
- 2.6. If 10 married someone with wavy hair, the first child would have wavy hair
- 2.7. If 1 and 2 had another child, the child would have curly hair.
- 2.8. If 3 and 4 had more children than those shown, they might have straight hair. (8)

QUESTION 3: - 6 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 punnett 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)

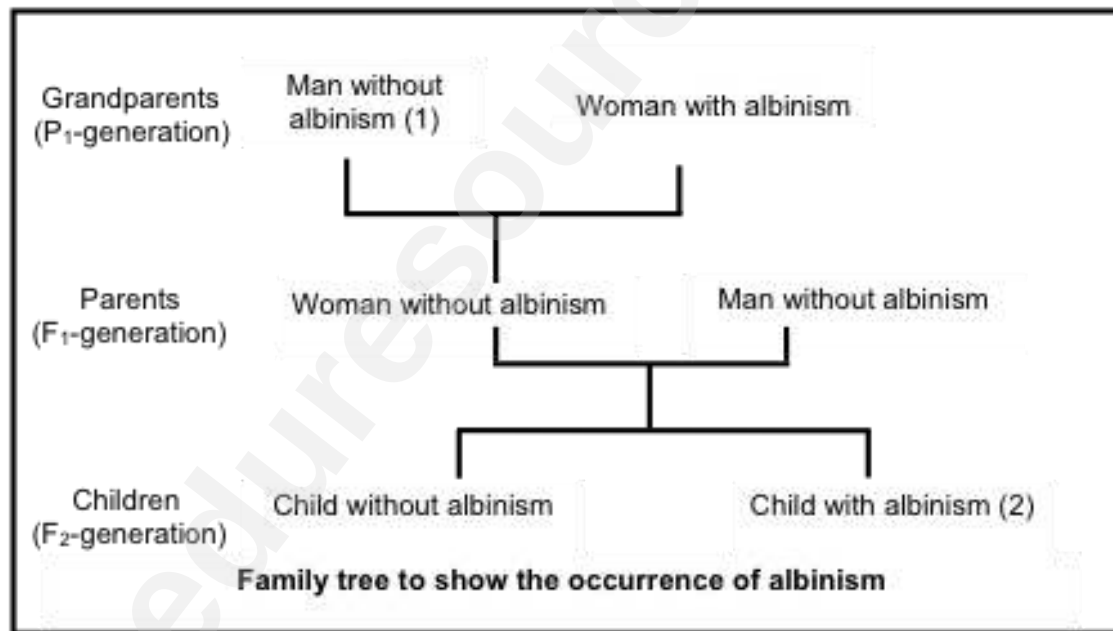
(Check the content summaries for the mark allocation for any cross that you do.

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 chart. Always first mark the homozygous recessive individuals on the chart 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

(b) 2

(3)

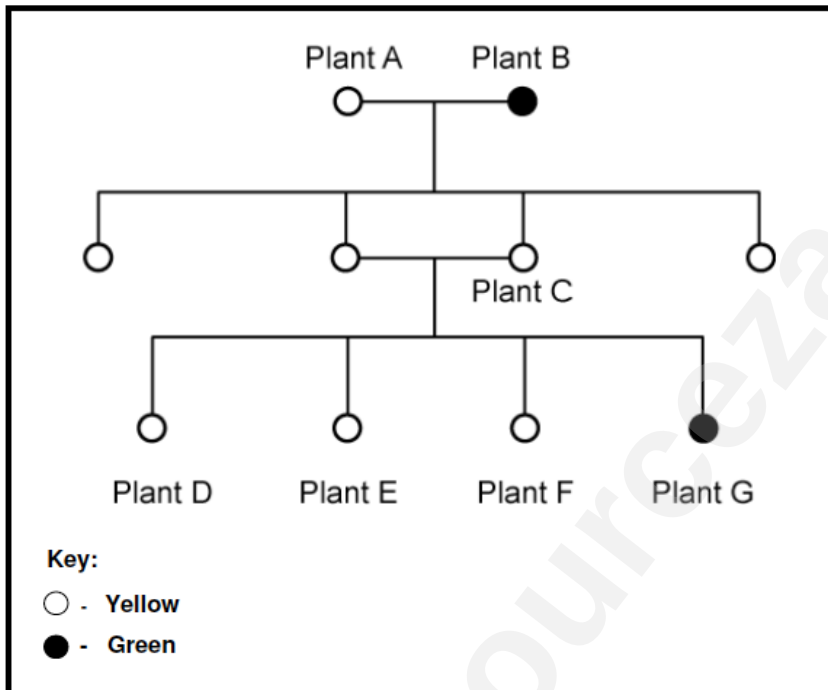
4.2. Explain your answer to QUESTION 4.1 (a).

(2)

QUESTION 5: – 6 minutes (Taken from Free State Prelim 2009)

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 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 follows:

(A reminder: yellow is dominant and green is recessive. For a pea plant to yield green peas, this plant must be 'yy' – so homozygous recessive)



- 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)

SECTION B: SOLUTIONS

- 1.1 D
- 1.2 C
- 1.3 B
- 1.4 B
- 1.5 C
- 1.6 A
- 1.7 C

(7)

- 2.1 A
- 2.2. C
- 2.3. A
- 2.4. B
- 2.5. D
- 2.6. D
- 2.7. C
- 2.8. D

(8)

3.

P₁ phenotype Black x Brown✓
 genotype Bb x bb✓

Meiosis

G B, b x b ✓

Fertilisation

F₁ genotype Bb and bb✓
 phenotype Black and brown✓

OR

gametes	b	b
B	Bb	Bb
b	bb	bb

1 mark for correct gametes

1 mark for correct genotypes

1 mark for stating **P₁ AND F₁**✓ (must have both)1 mark for stating **meiosis AND fertilisation** ✓ (must have both)

any 6 = (6)

4.1 (a) homozygous dominant✓ and heterozygous✓ (2)

(b) homozygous recessive✓ (1)

4.2 Normal is dominant and the dominant condition✓ can show up in either homozygous or heterozygous state✓

OR

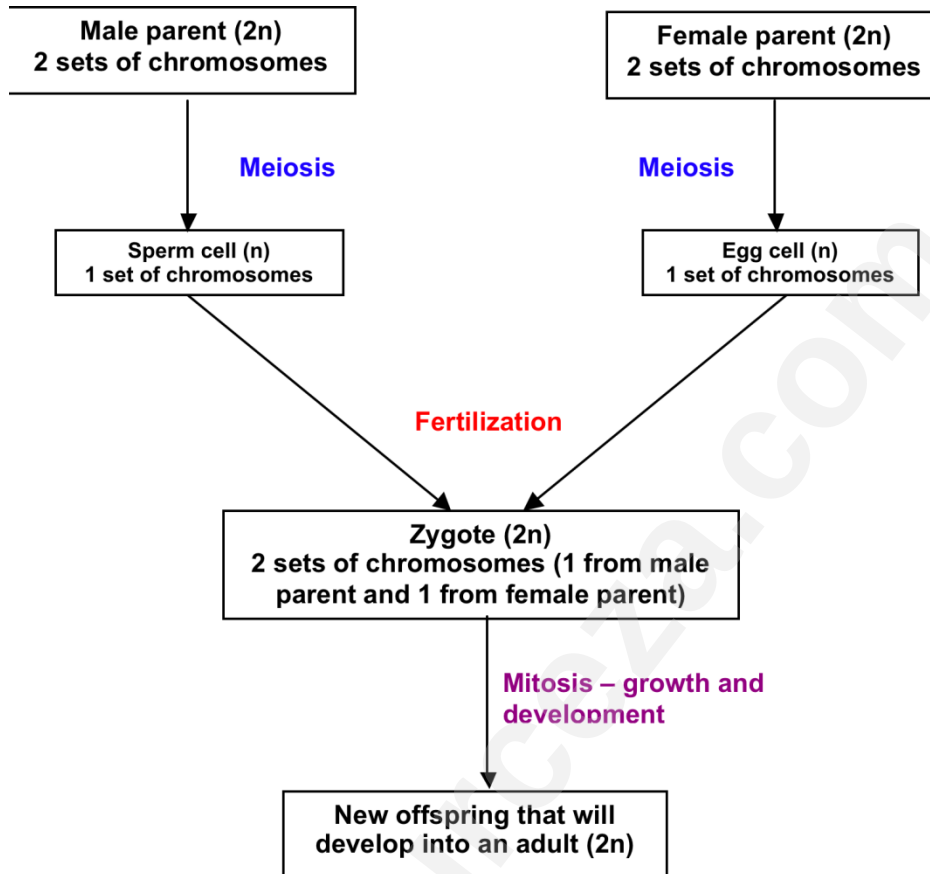
To have a normal child ✓ the person must have at least one dominant gene✓ / phenotype is normal (2)

5.1 Plant A - YY✓ Plant B - yy✓ (2)

5.2 Yellow: green ✓
= 3 : 1 ✓ (2)5.3 Phenotype – green peas ✓
Genotype – yy✓ (2)**SECTION C: ADDITIONAL CONTENT NOTES****1. Introduction:**

Genetics is a science. Genetics is the study of the principles of **heredity and variation**. A unique genetic code is found in the DNA of each organism and is passed on to the offspring during reproduction. Since there are **two parents** required for sexual reproduction, **genetic variation** will occur to ensure survival of the fittest.

2. The Role of Gametes in Inheritance

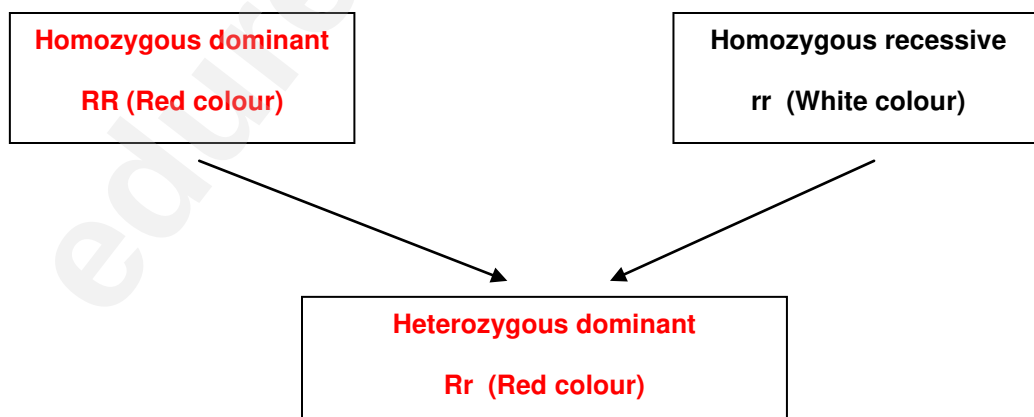


- DNA molecules on the chromosomes consist of sections called **genes**
- each gene contains the hereditary **traits**, e.g.: skin and hair colour, height, body structure and blood group are represented by the genes on each of the two homologous chromosomes
- in the process of Meiosis, **haploid** gametes are produced and the gametes will contain one set of genes
- during fertilization, the gametes fuse and a **diploid zygote** results
- one set of genes will come from the female parent and one set from the male parent
- the two sets of genes may be the same or different for a trait, e.g.: the mother may have black hair and the father may have blonde hair
- the offspring inherits two sets of genes, **50% from the mother** and **50% from the father** and will therefore be different from each of the parents
- the **diploid zygote** therefore contains a **double set of DNA** and is a **combination** of both parents

3. Genetic terminology

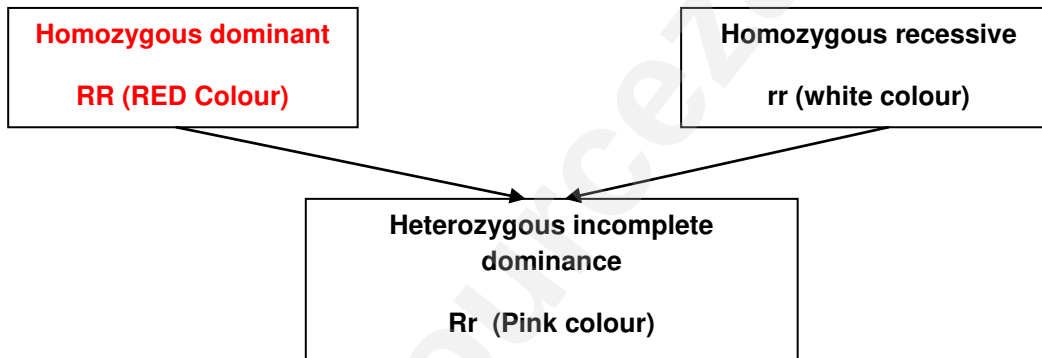
Genetics is a science and specific terms are used. Make sure that you know and understand the following terms very well as they form the basis for ALL the genetics that you will study.

- **Locus:** This is the exact position or **location** of a gene on a chromosome.
- **Alleles:** A pair of genes that are located at the **same point** on each of the two **homologous chromosomes** and represent a specific trait – one from the father and one from the mother.
- **Homozygous:** *Homo* = same and *zygous* = zygote. When two alleles of a pair of genes are the **same** for one trait e.g.: both alleles are for red flowers, the cross will result in a **pure breed** for red.
- **Heterozygous:** *Hetero* = different and *zygous* = zygote. When two alleles of a pair of genes are **different** for a trait e.g.: one of the alleles is for red flowers and one is for white flowers, the cross will result in a mixture of the two genes called a **hybrid**.
- **Dominant trait:** A heterozygous offspring will display the dominant trait because it will **dominate** over the other recessive gene of the allele pair, e.g.: red colour will **dominate over** the gene for white colour, so the offspring will look red.
The **dominant allele** is always written with a capital letter: **R** = red and **r** = white.
 - **Homologous dominant alleles** means that both genes are the **same** for the same dominant trait. It will be represented by **RR**, which represents both the genes for red flowers. The offspring will be red because **two dominant genes** are present.
 - **Heterozygous alleles** means that **one gene is dominant** and **one gene is recessive** for the same trait, e.g. red flowers. It will be represented by **Rr**, which represents one gene for red and one gene for white. The offspring will display red flowers, because red is **dominant** over white.



- **Recessive trait:** The recessive allele is the trait that **is dominated over** by the dominant gene. It is written with a small letter: **r** = white.
 - **Homologous recessive alleles** means that both recessive genes are the same, i.e.: **rr** – two genes for are present for white flowers. The offspring will display the **recessive white** colour only. The recessive trait will only ever be seen when it is in the homologous state.
 - **Heterozygous alleles** means that the genes are different with one gene dominant (red colour) and one gene is recessive (white colour) represented by **Rr**. The offspring will display red flowers because red is **dominant** over white which is **recessive**.
- **Incomplete dominance:** when the dominant gene allele is not able to completely dominate over the recessive gene allele, a mix of the two genes results, e.g.: red + white = pink. When the offspring is heterozygous with incomplete dominance, you will be able to see the combination of the two gene alleles

traits:



- **Genotype:** This is the **genetic** composition of an organism and represents the information that is present in the gene alleles, for example RR, Rr, rr. You **cannot see this because it is in the genes**.
- **Phenotype:** This is the **physical** appearance of an individual, i.e.: what you will see when you look at the offspring. The phenotype is determined by the genotype. You **will see** white flowers for rr, but you will see red flowers if the genotype is RR or Rr.

- **Monohybrid cross:** Mono = ONE so, when **one pair** of contrasting traits is crossed to determine the possible inheritance of the offspring. There will be 4 possible combinations that result from the cross –
2 possibilities from the male and 2 possibilities from the female ($2 \times 2 = 4$).

Female

	1	2
1		
2		

Male

Results in 4 combinations

- **Dihybrid cross:** Di = TWO, so when **two pairs** of contrasting traits are crossed to determine the possible inheritance of the offspring. There will be **16 possible combinations** that result from the cross – 2 possibilities from the male and 4 possibilities from the female ($4 \times 4 = 16$).
- **Filial generation:** The parents are represented by P_1 . The parents reproduce to produce offspring that result from the cross. The offspring are the **first filial generation** and this is represented by F_1 . When the offspring become mature and reproduce, they are represented by P_2 . Their offspring will be the second filial generation represented by F_2 .
- **Punnett square:** This is a schematic representation of a cross. Take careful note of the way the information is written. The example below: one parent is BB and the other is bb:
B = brown hair colour **b = blonde hair colour**

$P_1 \checkmark$ BB x bb $\checkmark$

$\checkmark$	gametes	B	B	$\checkmark$
	b	Bb	Bb	
	b	Bb	Bb	
$\checkmark\checkmark$				

$F_1 \checkmark$

Genotype: $\checkmark$ 4:4 Bb heterozygous offspring $\checkmark\checkmark$ (always include the ratios)
Phenotype: $\checkmark$ 100% brown $\checkmark\checkmark$ (always include the %)

SECTION D: HOMEWORK: (Taken from DoE Additional Exemplar 2008 Paper 1)

Learner Note: If you have difficulty with the Homework questions, you should refer to the Content notes, or refer to your class teacher for assistance.

1. 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)
2. 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)

SECTION E: SOLUTIONS TO SESSION 11 HOMEWORK

- 1.1. 4 ✓
- 1.2. $2n$ ✓ – 2 sets of chromosomes/ homologous pairs of chromosomes are present ✓
- 1.3. 2 ✓
- 1.4. n / haploid ✓
- 1.5. yes ✓ (6)
- 2.1. The number of Down's Syndrome babies increases ✓ as the age of the mother increases ✓
The incidence of Down's Syndrome babies increases rapidly after the age of 35 of the Mother ✓ (3)
- 2.2. normal baby = 46 chromosomes ✓, Down's syndrome baby = 47 chromosomes (2)
- 2.3. The learner agrees or disagrees with termination of the pregnancy. ✓ They must provide a reason for their answer that is valid and not just because they think so i.e.: religious beliefs, cultural beliefs, economic or psychological reasons etc. ✓ (2)