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MEIOSIS

! Learner Note: Briefly revise Mitosis. You must understand the difference between Mitosis and Meiosis. You must understand the relevance of the crossing over in Prophase 1 as this forms the basis and grounding for genetic variation and hereditary characteristics in Genetics and Reproduction. Learn the relevance of diseases and syndromes resulting from mutations caused during meiosis.

SECTION A: TYPICAL EXAM QUESTIONS - 35 MINUTES**QUESTION 1: Multichoice question: - 10 minutes**

(When answering multi choice: 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 sheet. BUT: If you do not know the answer after point 1 and 2 then: 3. Look at the options. 4. Try to think of why an option is wrong for the question and cross it. If there is an option that you don't know, write a ?. 5. If you still do not know the answer, then select the ?.)

1. The nucleus of the somatic cells of a human contains:
 - A. 46 identical chromosomes
 - B. 23 different chromosomes
 - C. 46 pairs of chromosomes
 - D. 23 pairs of chromosomes
2. Mitosis is responsible for the following in plants and animals
 - A. growth and repair
 - B. gamete formation
 - C. reduction division
 - D. genetic variation
3. The number of chromosomes in a zygote....
 - A. diploid
 - B. half the number in a gamete
 - C. haploid
 - D. triploid
4. Karyokinesis begins during which phase?
 - A. Prophase
 - B. Metaphase
 - C. Anaphase
 - D. Telophase
5. The most important reason for meiosis to take place is.....

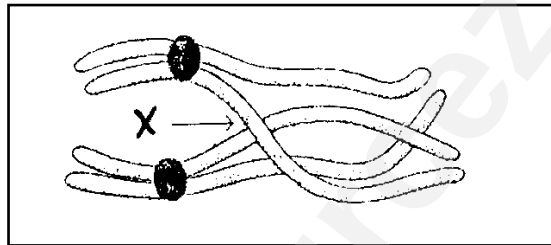
- A. the production of four gametes per mother cell to improve the chances of fertilization being successful
- B. the doubling of the chromosome number of each cell
- C. the production of haploid gametes to ensure that the chromosome number is diploid after fertilization
- D. the production of a diploid number of chromosomes in the gamete
6. During the process of meiosis....
- A. two identical daughter cells result
- B. four identical daughter cells are formed
- C. the chromosome number remains the same
- D. four unidentical daughter cells result
7. Cytokinesis is the
- A. division of the nucleus
- B. fusion of the nuclei
- C. division of the cytoplasm
- D. cytoplasmic streaming
8. When daughter cells with 20 chromosomes are formed by cell division, the following will result:
- A. 20 chromosomes after mitosis; 20 chromosomes after meiosis
- B. 20 chromosomes after mitosis; 10 chromosomes after meiosis
- C. 40 chromosomes after mitosis; 20 chromosomes after meiosis
- D. 10 chromosomes after mitosis; 10 chromosomes after meiosis
9. Place the following steps that occur in meiosis in order:
1. crossing over of the chromatids
 2. lining up of paired chromosomes at the equator
 3. pairing of homologous chromosomes
 4. complete separation of chromatids
- A. 1, 2, 3, 4
- B. 2, 3, 4, 1
- C. 3, 1, 2, 4
- D. 4, 1, 2, 3
- (With this type of question, read through options 1 to 4 and tick those that are correct and apply to the question. Cross those that do not. Select your answer from the ticked options)**
10. Why does crossing over /chiasma take place during meiosis?
- A. to ensure that the chromosomes divide evenly

- B. to ensure that characteristics from the mother are transferred to the father
- C. to ensure that cell division can take place
- D. to ensure that that genetic variation is passed on to all offspring (10)

QUESTION 2: - 8 minutes*(Taken from Viva Life Science – Grade 12)*

(When doing any question about Meiosis remember that crossing over during Meiosis Prophase I AND the random assortment of the chromosomes during Meiosis Metaphase I is what results in variation. You must know this for Genetics and also to understand Diversity)

Study the diagram below and answer the questions that follow:

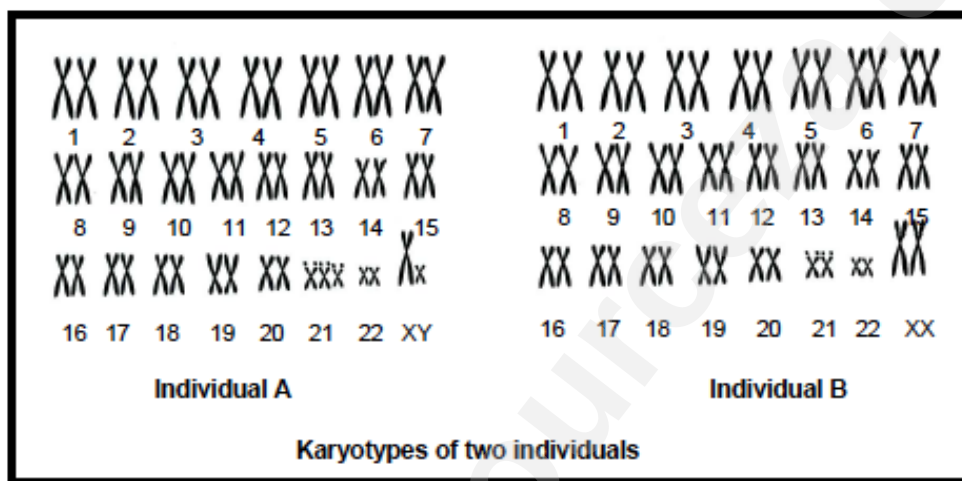


- 2.1. Name the process occurring in the diagram. (1)
- 2.2. Provide a label for the region marked X. (1)
- 2.3. During which phase of meiosis does this process occur? (2)
- 2.4. List ONE importance of this process to living organisms. (1)

QUESTION 3: – 8 minutes (Taken from DoE Exemplar 2008 Paper 1)

(Remember that the human genome is the 'blue print' for each individual's chromosome pairs. It determines and represents our individual karyotype (chromosome sets). The gonosomes will be XX in females and XY in males. Humans have 23 pairs of chromosomes – 23 from the mother and 23 from the father = 23 pairs. When there are 1 or 2 chromosomes too many in the karyotype, genetic/chromosomal disorders will result)

The diagrams below show the sets of chromosomes (karyotypes) in two human individuals, A and B. Study the diagrams and answer the questions that follow.



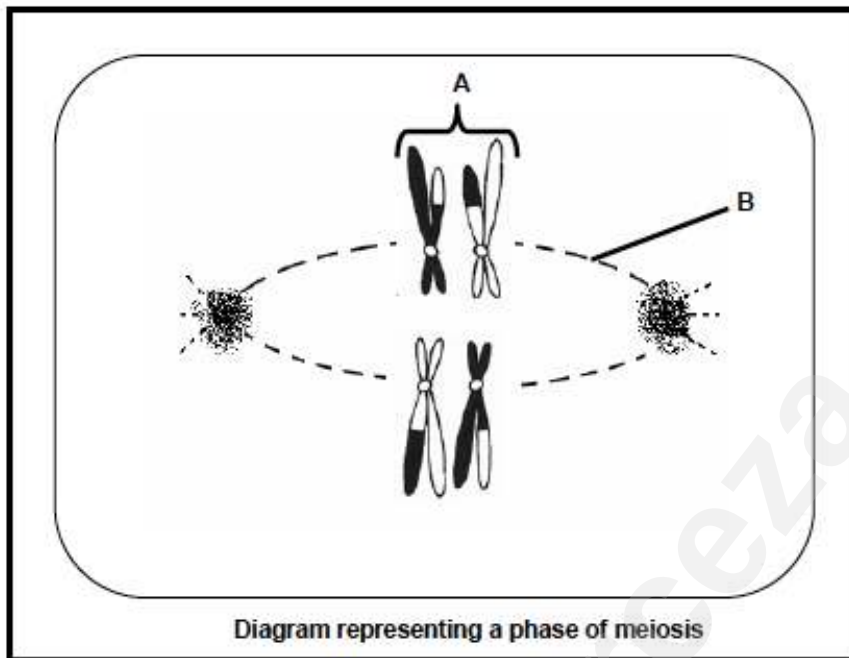
- 3.1 Which individual (A or B) is female? (1)
- 3.2 Give a reason for your answer to QUESTION 3.1. (2)
- 3.3 Identify which individual (A or B) has an abnormal number of chromosomes. (1)
- 3.4 Name the genetic disorder that the individual in QUESTION 3.3 has. (1)
- 3.5 Explain the abnormal chromosome number of the disorder named in QUESTION 3.4. (2)

QUESTION 4: – 8 minutes

(Taken from DoE Exemplar 2008 Paper 1)

(You must be able to identify the various phases of Meiosis from a diagram)

The diagram below represents a phase of meiosis. Study the diagram and answer the questions that follow.



- 4.1 Write down the term that best describes the paired chromosomes labelled A. (1)
- 4.2 Identify structure B. (1)
- 4.3 What phase of meiosis is represented in the diagram above? (2)
- 4.4 How many chromosomes are shown in the diagram above? (1)
- 4.5 How many chromosomes would there be in each cell at the end of meiosis? (1)

SECTION B: SOLUTIONS

- | | | | | |
|--------|--------|--------|--------|--------------|
| 1.1. D | 1.2. A | 1.3. A | 1.4. B | 1.5. C |
| 1.6. D | 1.7. C | 1.8. B | 1.9. C | 1.10. D (10) |

- 2.1. crossing over ✓
- 2.2. X – chiasmata ✓ (this is the actual point where the chromosomes touch)
- 2.3. prophase I ✓✓ (Reminder: the 'I' means meiosis I / 1st meiotic division. So a 'II' like e.g.: metaphase II will mean that this is metaphase in the 2nd meiotic division)
- 2.4. To ensure genetic variation ✓ in the organism. (5)

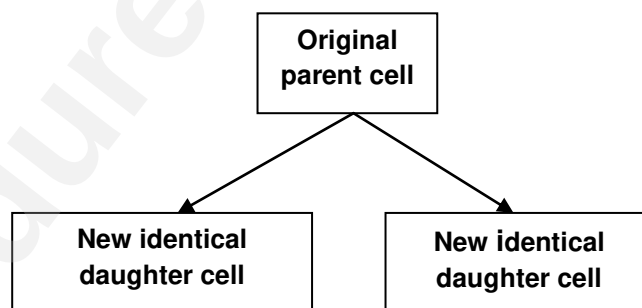
- 3.1 B (1)
- 3.2 XX✓chromosomes✓/ Two identical sex chromosomes ✓✓ (any 2)
- 3.3 A (1)
- 3.4 Down's syndrome (**Reminder: 23 + 24 = 47 chromosomes**) (1)
- 3.5 Caused by a faulty meiotic division✓/oogenesis during production of the ovum✓/spermatogenesis during sperm production✓ (any 1)
- The chromosomes of chromosome pair 21 fail to separate✓
- 4.1 Homologous (1)
- 4.2 Spindle thread/spindle fibre (1)
- 4.3 Metaphase 1 (2)
- 4.4 4 (1)
- 4.5 2 (1)

SECTION C: ADDITIONAL CONTENT NOTES

1. Introduction

In mitosis you learned how the chromosomes carry the genes that hold the information for each individual. During the process, the chromosomes duplicate to form **two identical daughter cells**. When cells are damaged, the surrounding cells will duplicate by mitosis and form new identical cells. Mitosis will take place to ensure:

- **growth of the organism**
- **repair of damaged cells**
- **replacement of cells that cannot be repaired**
- **reproduction in single-celled organisms** (only one cell so they do not have reproductive structure and reproduce by duplicating the parent cell)



2. The Process of Meiosis

For sexual reproduction to take place, a haploid male gamete will fuse with a haploid female gamete during **fertilisation**. The result is a diploid **zygote**.

haploid + haploid	= diploid
half + half	= whole

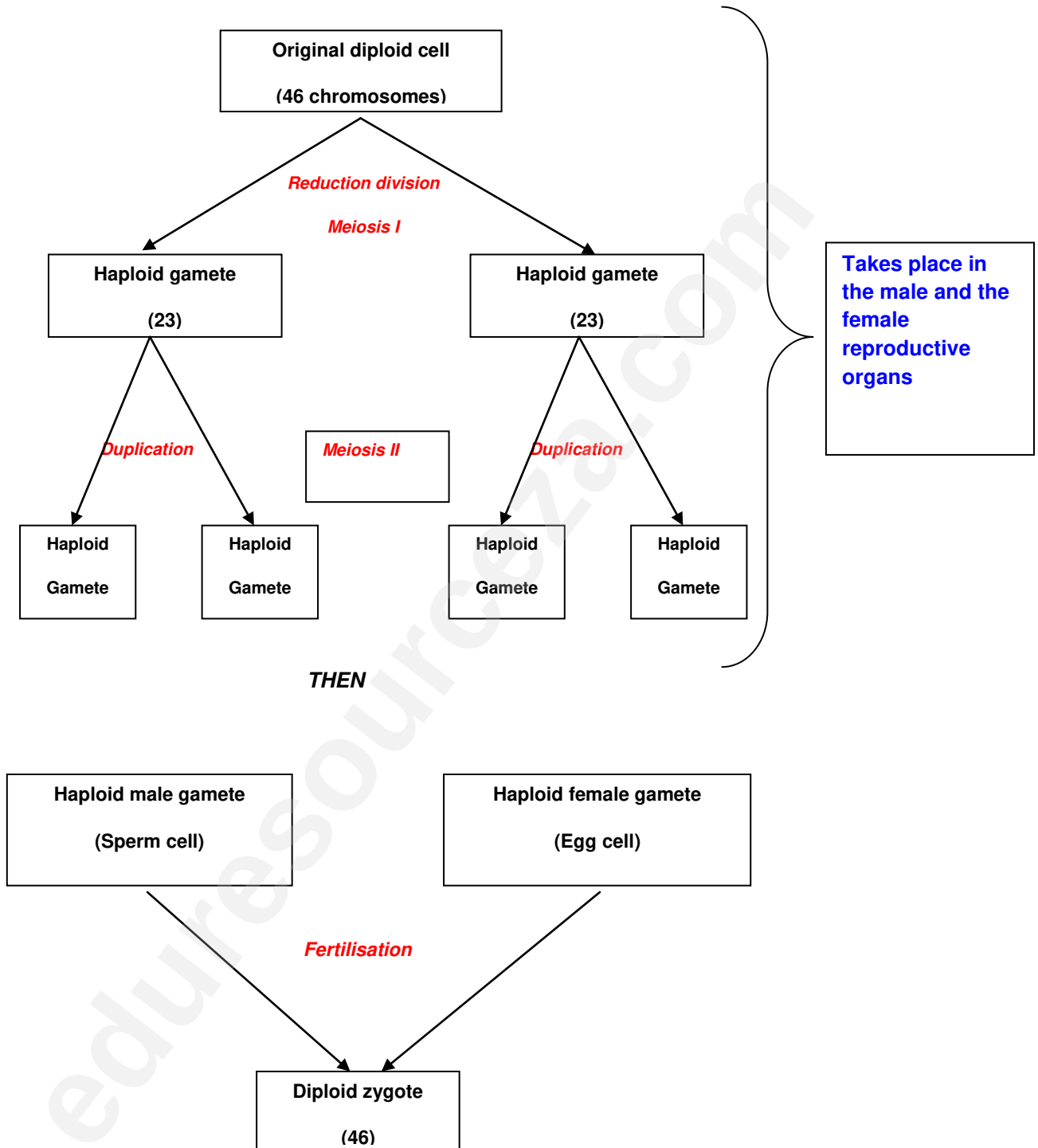
- Each gamete contains **half** of the chromosomal number of the body cells. This means that each gamete must contain one set of the double set of chromosomes in the original cell nucleus.
- The process of meiosis takes place so that each gamete contains **one complete set** of chromosomes.
- The zygote will contain **two complete sets** of chromosomes – one from the male gamete and one from the female gamete.
- The growth and development of the zygote will then occur by the process of mitosis.

In humans, each body cell contains **46 chromosomes** (diploid). One set of 23 chromosomes will come from the mother in the egg cell (haploid female gamete). The second set of 23 chromosomes will come from the father in the sperm cell (haploid male gamete). When there are two sets of chromosomes, the nucleus is diploid ($2n$) and complete. When we refer to **one set** of chromosomes in the gamete, it is called **haploid (n)**. Haploid represents 23 chromosomes and diploid represents 46 chromosomes.

The two steps of the meiosis process:

- Meiosis I (first meiotic division):** this is called reduction division where the chromosome number in the nucleus is halved. The resulting gametes are haploid.
- Meiosis II (second meiotic division):** this process is similar to mitosis. The haploid gametes duplicate so that in males, four sperm cells result. In females, one gamete forms the egg cell and the three remaining gametes provide nutrition for the egg cell.

The process of Meiosis simplified:



3. Significance of Meiosis

The process of meiosis takes place to:

- Produce haploid gametes from diploid chromosome pairs, in preparation for sexual reproduction
- the formation of haploid sperm cells during meiosis is called spermatogenesis
- the formation of haploid egg cells during meiosis is called oogenesis
- Ensure that the chromosome number remains the same in the offspring as in the adult ($n + n = 2n$)
- Ensure genetic variation when crossing over takes place during Prophase I

4. The Production of Sex Cells

The production of sex cells is grounding for Reproduction and Genetics. Meiosis takes place in specialized cells located in the reproductive system, to ensure sexual reproduction:

In animals:

- male gametes/spermatozooids are produced in the **testes**
- female gametes/egg cells are produced in the **ovaries**
- special cells in the pollen sacs of the anthers divide by meiosis to produce the **pollen grains** containing the male gametes
- a specialised cell in the ovule divides by meiosis to produce the **embryo sac** containing the egg cell

In plants:

The 23 pairs of chromosomes that result in a zygote are divided as follows:

- 22 pairs of autosomes
- 1 pair of sex chromosomes represented by
XX in females
XY in males

A **karyotype** is a set of chromosomes from a human cell, that shows the chromosomes arranged according to their numbers. Number 1 is always the largest while number 22 is the smallest. The female karyotype will have XX as number 23 and the male will show XY as number 23. See the following karyotypes.

5. Diseases and syndromes

Sometimes changes take place in the chromosome number during meiosis. Each nucleus should contain 23 chromosomes after meiosis but if one nucleus contains 22 while the other has 24, it creates problems. When either of these resulting gametes joins with a normal gamete, the result could be:

$23 + 22 = 45$ or $23 + 24 = 47$ chromosomes. If this happens, abnormalities result.

- **Down's Syndrome:** The Down's syndrome baby has 47 chromosomes. The mother's egg cell has 24 chromosomes + the father's sperm cell that has 23 chromosomes. The

child will have 45 autosomes, with three number 21 chromosomes instead of the normal pair and one pair of sex chromosomes. Women over the age of 40 have a 1/12 chance of producing gametes that have 24 chromosomes.

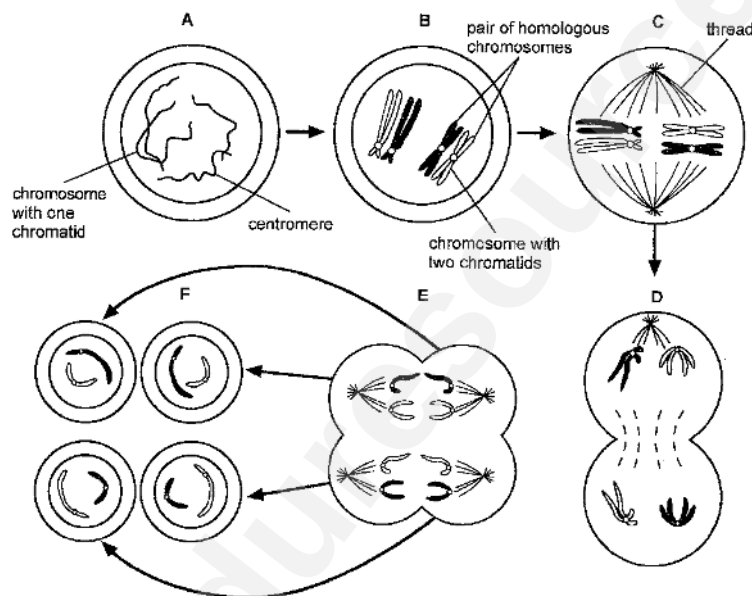
- **Klinefelter's Syndrome:** Klinefelter's syndrome results from 47 chromosomes. The baby has 44 autosomes and three sex chromosomes - XXY. It is a relatively common genetic abnormality and occurs in 1/500 males.
- **Turner's Syndrome:** Turner's syndrome results when one of the X chromosomes is absent from the male or female gamete. The baby has 44 autosomes and only one X chromosome. This disorder occurs in 1/3000 births as 95% of the foetuses are spontaneously miscarried.

SECTION D: HOMEWORK

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

QUESTION 1:

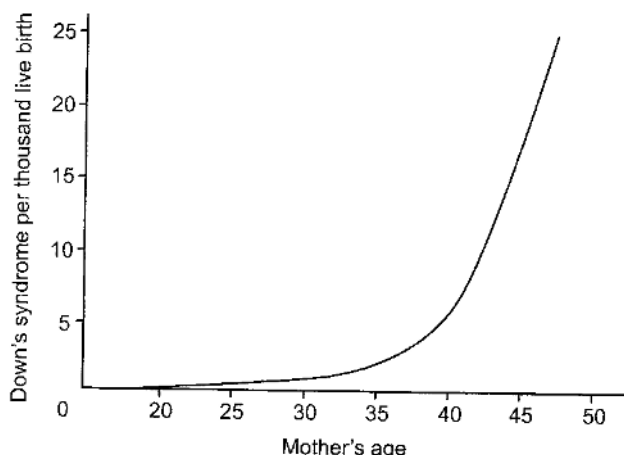
Study the diagrams below on the principle of meiosis. Answer the questions that follow:



- 1.1. How many chromosomes does cell B have? (1)
- 1.2. Would this be n or $2n$? Give a reason for your answer. (2)
- 1.3. How many chromosomes does each cell in F have? (1)
- 1.4. What would the ploidy of each cell in F be? (1)
- 1.5. Does each cell in F have exactly the same number of chromosomes? (1)

QUESTION 2:

The graph below shows the relationship between the number of babies born with Down's syndrome and the age of the mother.



- 2.1. Discuss the shape of the graph. (3)
- 2.2. What is the difference in the number of chromosomes between a normal baby and a baby with Down's syndrome? (2)
- 2.3. What is your view on the termination of pregnancy if a woman discovers she is carrying a foetus with Down's syndrome? Support your answer with a reason. (2)

SECTION E: SOLUTIONS TO SESSION 10 HOMEWORK

1. The father is 2. ✓ There are 5 matches ✓ in the VNTR. ✓ (3)

2. Protein synthesis - the process:
Step 1: Transcription

- The enzyme RNA polymerase causes the DNA to unwind and separate in the nucleus. ✓
- One DNA strand provides the code which is copied onto an mRNA strand in the nucleus. ✓
- Each mRNA strand consists of three bases called a codon, per DNA code triplet. ✓
- **This process of copying the triplet code onto the mRNA is called transcription.** ✓
- When the **mRNA is coded**, it leaves the nucleus through the nucleopore ✓ and carries the message as a codon to the ribosomes ✓ in the cytoplasm. The codon will provide the ribosome with the code to synthesise a specific piece of a protein. ✓

Step 2:

- **tRNA has an anticodon** – it has the opposite bases to the codon. ✓
- It picks a specific amino acid and carries it to the ribosome ✓ where mRNA codon determines the **anticodon fit**. ✓
- The tRNA carries the amino acid to the ribosomes according to the template formed by the codon of the mRNA. ✓
- The mRNA will therefore determine which anticodons will fit ✓

Step 3:

- The tRNA releases the amino acid ✓ into the correct place on the polypeptide chain (many peptides) and leaves to collect the next amino acid. ✓
- The processing of the information carried by the mRNA ✓ into an amino acid sequence during protein synthesis is known as translation. ✓ (16)

3.

- Process to produce specific proteins required for cells, antibodies, blood, enzymes and hormones (1)
- Proteins are a reserve energy source in the body (1)
- Nucleoproteins present in the chromosomes are important for cell division and heredity (1)
- Conjugated proteins like haemoglobin (transports oxygen to all the cells in the body) and lipoproteins (necessary to form cell membranes and organelles) are essential for the body to function properly. (1)

any 3 reasons**(3)**