

# SENIOR SECONDARY IMPROVEMENT PROGRAMME 2013



## GRADE 12

## LIFE SCIENCES

## LEARNER NOTES

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## LEARNER NOTES

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**SELF STUDY TOPIC 1: CONSOLIDATION EXERCISE - MEIOSIS AND DNA**

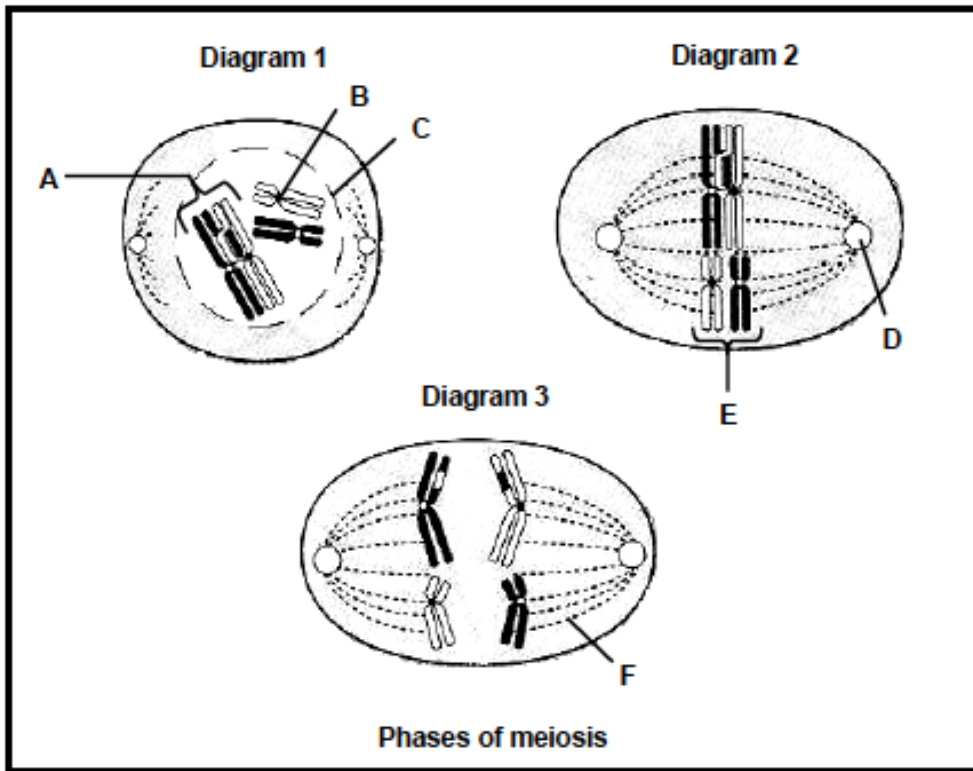
**Learner Note:** Please take careful note of the time allocation. You will only be allowed the specific time allocated, to complete each question. When there are diagrams, remember that you must always first write in the labels that you know, onto the diagrams before answering the questions that follow below. Underline important information that is given to you in the question. Remember to underline the words that indicate what the question is asking. Take careful note of the mark allocations.

**SECTION A: TYPICAL EXAM QUESTIONS**

**QUESTION 1:** 13 minutes (Taken from DoE Additional Exemplar 2008 Paper 1)

The diagrams below represent phases of meiosis.

(Remember to label the diagram first before going on to the questions.)



- 1.1 Name the process taking place at A. (1)
- 1.2 Identify structures B, C, D and E. (4)
- 1.3 State ONE function of F. (2)
- 1.4 What phase of meiosis is represented in Diagram 2? (2)
- 1.5 Give a reason for your answer to QUESTION 1.4. (2)
- 1.6 How many chromosomes are shown in Diagram 3? (1)
- 1.7 Name ONE organ in the human female body where the process of meiosis will occur. (1)

[13]

**QUESTION 2:** 7 minutes (Taken from DoE Additional Exemplar 2008 Paper 1)

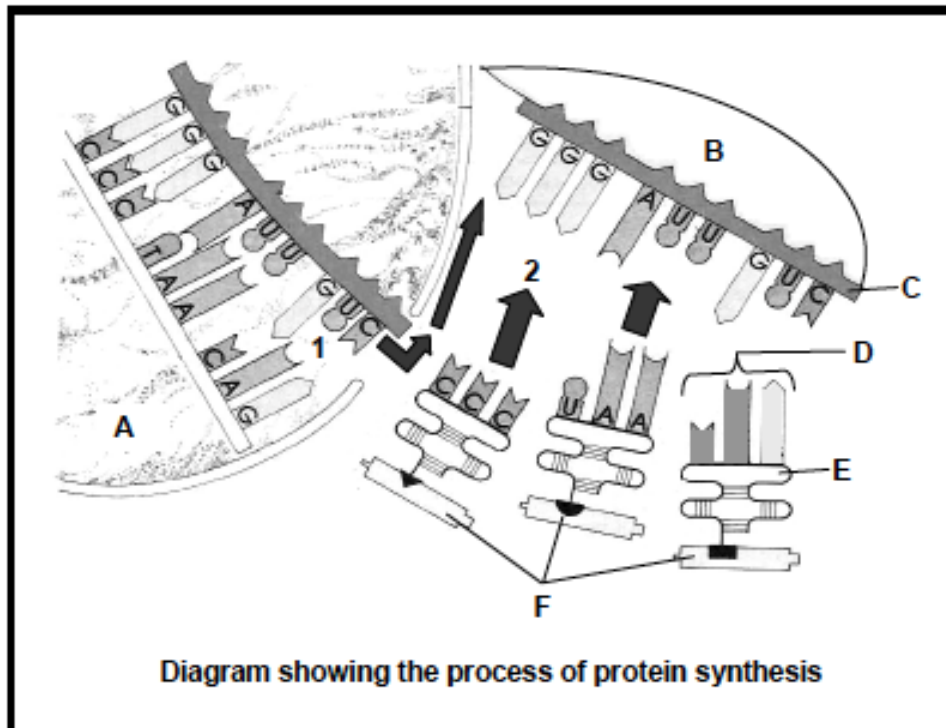
Tabulate THREE differences between DNA and RNA.

(Remember to give your table a suitable heading/caption. Compare the same characteristics for each of the columns.) [7]

**QUESTION 3:** 10 minutes (Taken from DoE Additional Exemplar 2008 Paper 1)

Study the diagram below which shows the process of protein synthesis.

(Remember to label the diagram first and then move onto the questions.)



- 3.1 Identify organelles A and B respectively. (2)
- 3.2 Label structures C, E and F respectively. (3)
- 3.3 Which stage of protein synthesis is represented at:  
 (a) 1? (1)  
 (b) 2? (1)
- 3.4 Write down the anticodon that reads from left to right at D. (3)
- [10]

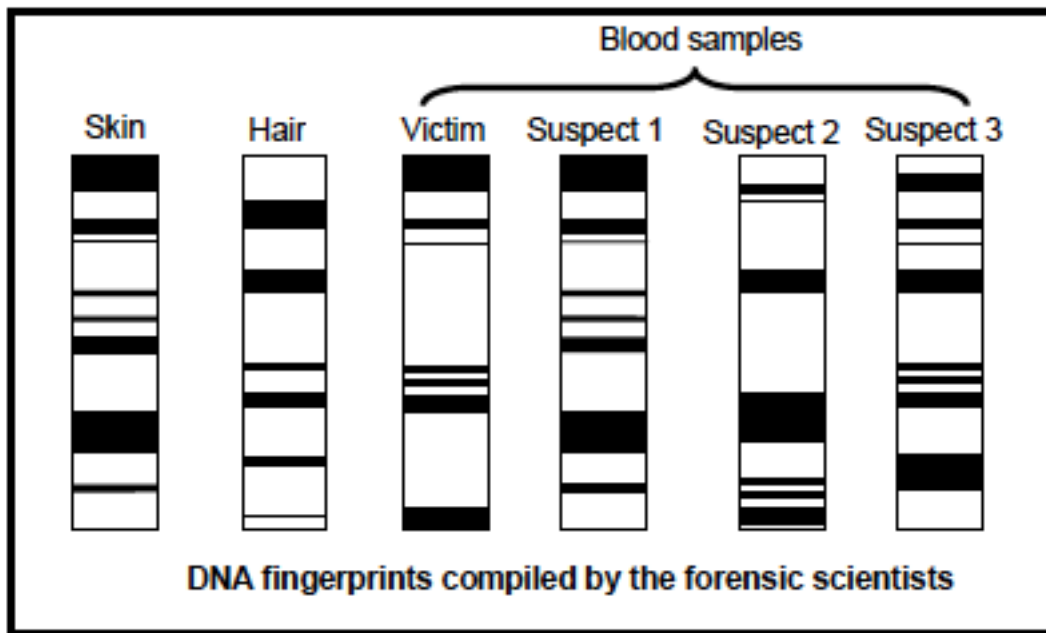
**QUESTION 4:****10 minutes***(Taken from DoE Exemplar 2008 Paper 1)*

A woman was found stabbed to death in a hotel. The police found a few strands of hair in her one hand. There was also skin tissue under her long nails.

Forensic scientists took blood samples from three suspects to compile DNA fingerprints. DNA fingerprints were also compiled from the victim's blood and the hair and skin tissue found in the victim's hands.

The following diagram shows the DNA fingerprints of the hair sample, the skin tissue sample and blood from the victim and the three suspects.

**(Remember to use a ruler horizontally so that you do not make a mistake when comparing the VNTR markers.)**



- 4.1 Did the DNA from the hair and skin tissue come from the same person? (1)
- 4.2 What conclusion can you make from QUESTION 4.1 about the possible number of people involved in the murder? (2)
- 4.3 Which of the three suspects might have been involved in the murder? (1)
- 4.4 Give a reason for your answer to QUESTION 4.3. (1)
- 4.5 Do you think that the DNA evidence on its own is enough to convict a suspect? (1)
- 4.6 Give a reason for your answer to QUESTION 4.5. (2)
- 4.7 Explain whether the collection of DNA from every citizen in South Africa to create a DNA fingerprint database is a good idea or not. (2)

[10]

## SELF STUDY TOPIC 2: CONSOLIDATION EXERCISE - MEIOSIS AND HUMAN FINGERPRINTING

**Learner Note:** The consolidation exercises have been extracted from past examination papers to assist you to assess yourself, and to assist you with exam techniques and time allocation. Please ensure that you adhere to the time allocations. We suggest the following:

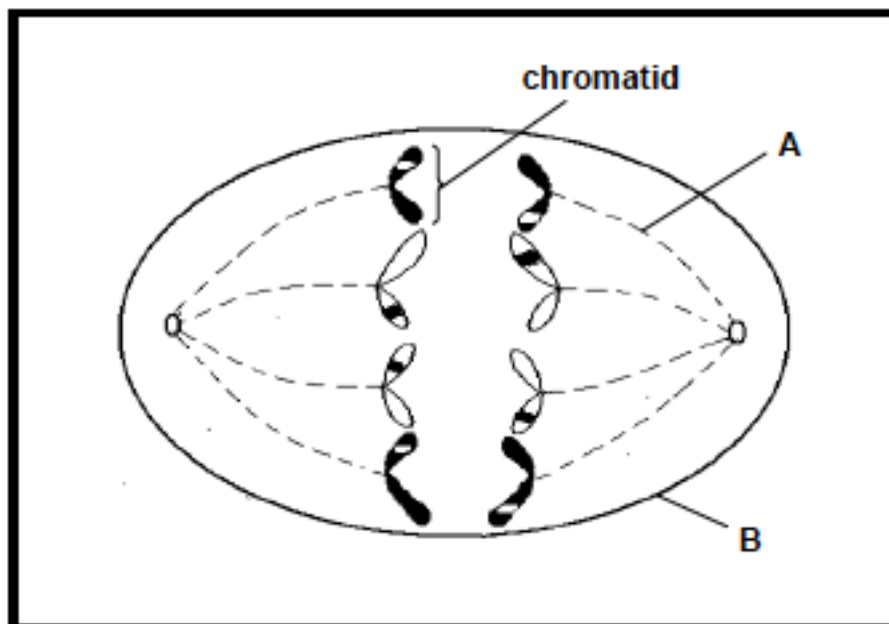
- Read through the question first.
- Check the important words and underline these words.
- Take careful note of the marks per question, then start the question and the time.
- After the allocated period, stop and begin to go through the next question and follow the same process.
- If you have not completed a question, you must complete it when your teacher works through the memo.
- You will lose the marks for the questions that you have not completed.
- You **MUST** work fast but correctly.

### SECTION A: TYPICAL EXAM QUESTIONS

**EXERCISES:** 60 minutes including going through the memo.

**QUESTION 1:** 13 minutes

The diagram below represents an animal cell in a phase of meiosis.



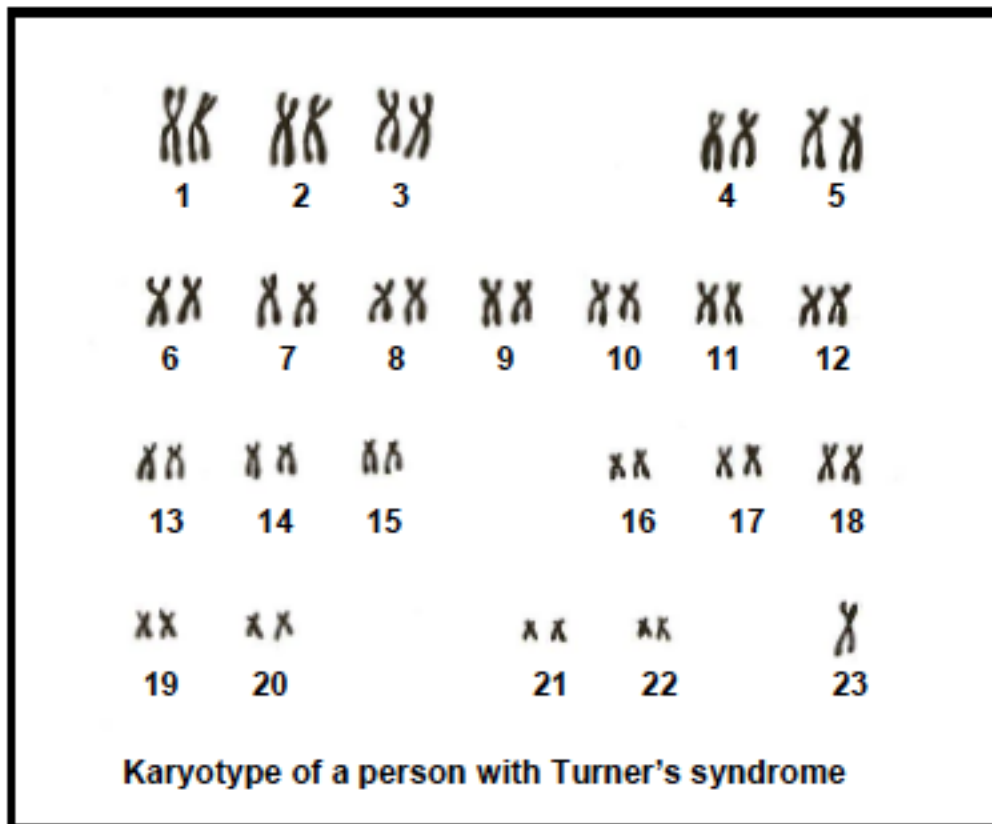
**Remember** to complete the labels before you move on to the questions.

- 1.1 State which **phase of meiosis** is represented in the diagram above. (1)
- 1.2 Give a reason for your answer to QUESTION 1.1. (2)
- 1.3 Identify parts A and B. (2)

- 1.4 How **many chromosomes** ...
- (a) were present in the parent cell **before** it underwent **meiosis**? (1)
- (b) will be present in each cell at the **end** of the **meiotic division**? (1)
- 1.5 State ONE place in the body of a human **female** where meiosis would take place. (1)
- 1.6 Could the cell represented in the diagram be that of a **human**? (1)
- 1.7 Explain your answer to QUESTION 1.6. (2)
- 1.8 Give **TWO reasons** why meiosis is **biologically important**. (2)
- [13]

**QUESTION 2: 4 minutes**

Study the karyotype below of a person suffering from Turner's syndrome. Females with Turner's syndrome do not develop mature sex organs.

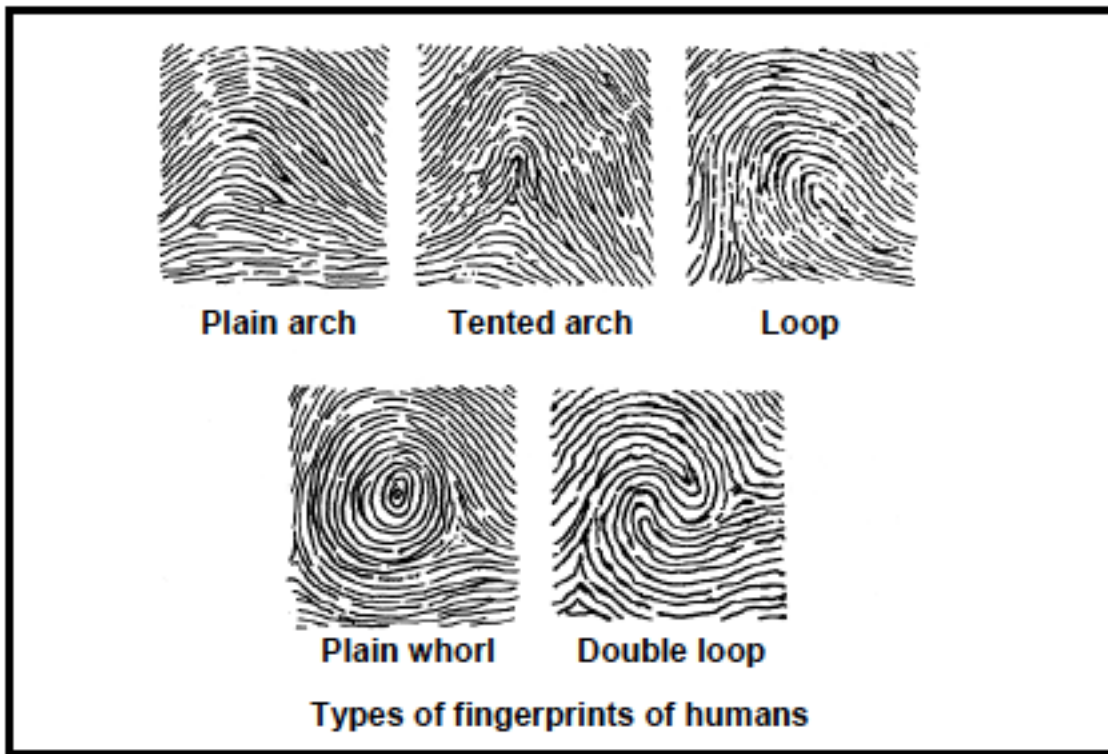


**Remember:** there are 44 autosomes and only one X chromosome. Chromosome pair 23 is the sex chromosomes: in males XY and in females XX normally.

- 2.1 State the **differences** between the karyotype for a **normal female** and a female with **Turner's syndrome**. (2)
- 2.2 Explain **ONE effect** of the disorder in a female. (2)
- [4]

**QUESTION 3: 13 minutes**

Humans show differences in characteristics such as fingerprints. Humans have **five main types** of fingerprints as shown in the diagram below:



A fingerprint is a useful way of **identifying people** and **classifying** them into groups. A fingerprint is taken by rolling the right index finger onto an ink pad and then onto a piece of paper.

During a discussion of this topic, a group of learners asked the following question: "Which one of the five main types of fingerprints is **most common** amongst the learners of this school?"

- 3.1 State any **FOUR steps** in the planning process that must be considered when **planning an investigation** to answer the question above. (4)
- 3.2 The learners carried out an investigation and the results are shown in the table below.

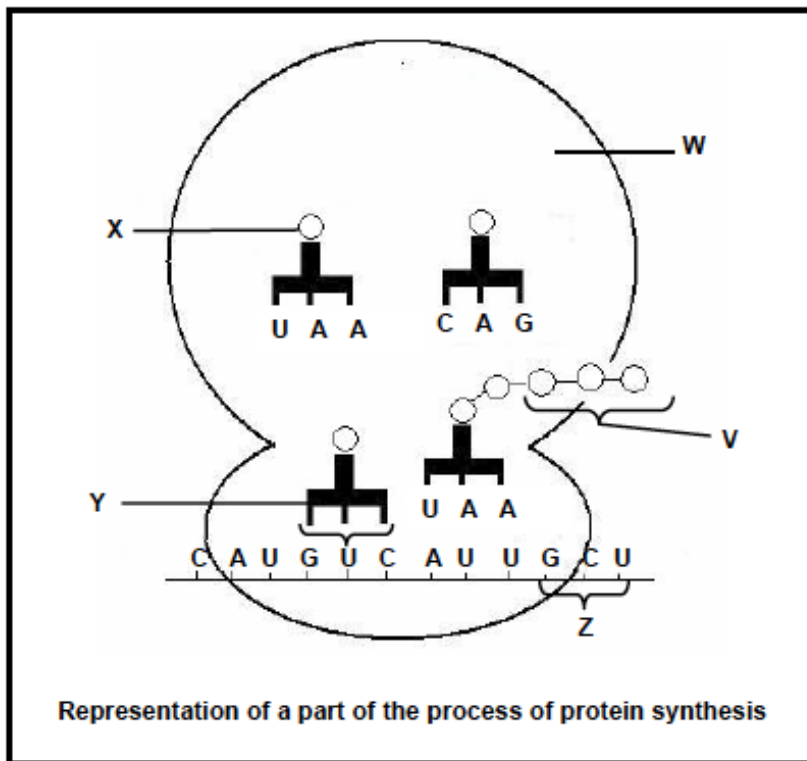
Main types of fingerprints	Number of learners
Plain arch	123
Tented arch	112
Loop	124
Plain whorl	150
Double loop	50



- (a) Give a **caption** for the table. (2)  
**(Remember that a caption is a heading where the words 'types of fingerprints' and 'learners' would have to be included since these are the headings of the two columns.)**
- (b) Learners came to the following conclusion:  
*Most learners have the plain arch-type fingerprint.*  
 Is this a valid conclusion? (1)  
**(Remember that validity is based on the numbers, the accuracy and similar conditions like ages, males/females as applicable, etc.)**
- (c) Give a reason for your answer to QUESTION (b). (2)
- 3.3 State the following:
- (a) **TWO advantages** of having a fingerprint database of every citizen and visitor in South Africa (2)
- (b) **TWO disadvantages** of having a fingerprint database of every citizen and visitor in South Africa (2)
- [13]

**QUESTION 4: 9 minutes**

The diagram below represents a part of the process of protein synthesis.



- 4.1 Name the part/**stage of protein synthesis** that is illustrated in the diagram above. (1)
- 4.2 Name the organelle labelled W. (1)

4.3 The table below shows the base triplets of mRNA that correspond to the different amino acids.

mRNA	AMINO ACID
CAU	histidine
AUU	isoleucine
GUC	valine
CUU	leucine
GCU	alanine
CCU	proline
CGA	arginine

With reference to the diagram in QUESTION 4 above:

- Name the amino acid labelled X. (1)
- State the base sequence of the molecule labelled Y. (1)
- What **collective name** is given to the triplet of mRNA bases that correspond to each amino acid? (1)
- How would the **composition** of the protein molecule change if the base sequence at Z was CGA instead of GCU? (2)

4.4 Use the information in the table to write the **DNA base sequence** that would correspond with the amino acid **histidine**. (2)  
[9]

**TOPIC 1: MENDEL'S 1<sup>ST</sup> LAW, SEX AND BLOOD GROUP DETERMINATION**

**Learner Note:** Mendel's Laws are very important and you must understand the basic concepts of Genetics. You must 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. "Crossing over" takes place in meiosis during prophase where pieces of chromosomes cross over from the male chromosomes to the female chromosomes to ensure a mix of the characteristics 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 during examinations. The more examples of genetic crosses you do, the better you will be at doing this.

**SECTION A: TYPICAL EXAM QUESTIONS (Please adhere to the time allocations.)**

**QUESTION 1: 6 minutes** (*Taken and adapted from Study & Master Biology Grade 11*)

Blood typing can be used to identify a parent in that the blood type can prove that a person is not the parent of a child rather than determine without question who the parent is. A, B, AB and O blood groups are the result of three alleles. Allele A and B are co-dominant and O is recessive to both A and B. Should the discrepancy continue, tissue typing and DNA fingerprinting will be used. Read through the following information and answer the questions below:

In a maternity ward of a hospital, two newly born babies were mixed up. One baby is blood type O and the other is type A. Both mothers believe the baby with blood type O is their baby. Can you sort it out?

On testing the parents' blood it was found that:

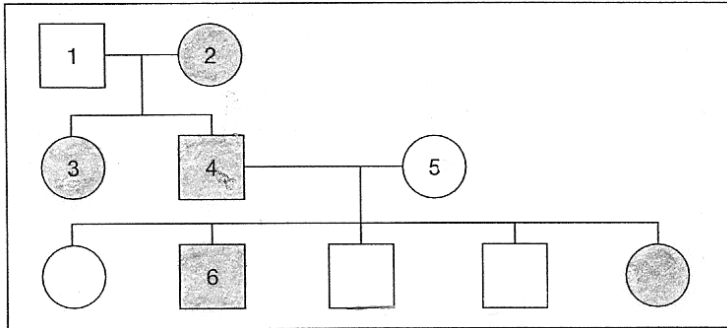
1. Mr. Xhosa is blood group AB and his wife is blood group B
2. Mr. Mbundwini is type A.

Who owns baby 'O' and who owns baby 'A'? Explain / show your reasoning. [6]

**HINT:** 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 2: 11 minutes***(Taken and adapted from Study&Master Biology Grade 11)*

The diagram below shows the inheritance of eye colour in humans. The squares represent men and the circles, women. The individuals represented in shaded symbols have brown eyes and the unshaded symbols have blue eyes. Brown eye colour (B) is dominant over blue eye colour (b).



- 2.1. Use the letter B and b as indicated and write down the genotypes of the individuals numbered 1 to 5. (5)

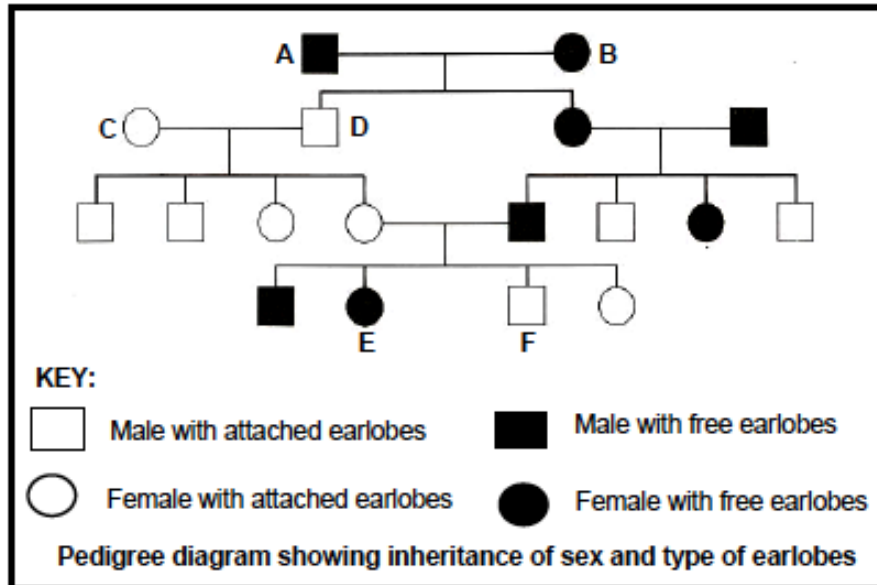
**HINT:** Remember that genotype will be what is in the genes and not what you can see.

- 2.2. Draw a diagrammatic representation of all the genetic combinations with regard to eye colour, of the descendants when 6 marries a woman with the same genetic composition as 3. Use the letters B and b to show the genotype and phenotype of this F<sup>1</sup> generation. (6)  
[11]

**HINT:** Remember to use a Punnett square. Refer to your notes to check that you write all the information required or you will lose unnecessary marks.

**QUESTION 3: 13 minutes***(Taken from DoE Additional Exemplar 2008 Paper 1)*

Study the family tree on below, which shows the inheritance of sex and type of earlobes over four generations of a family. In humans, free earlobes (F) is dominant over attached earlobes (f).

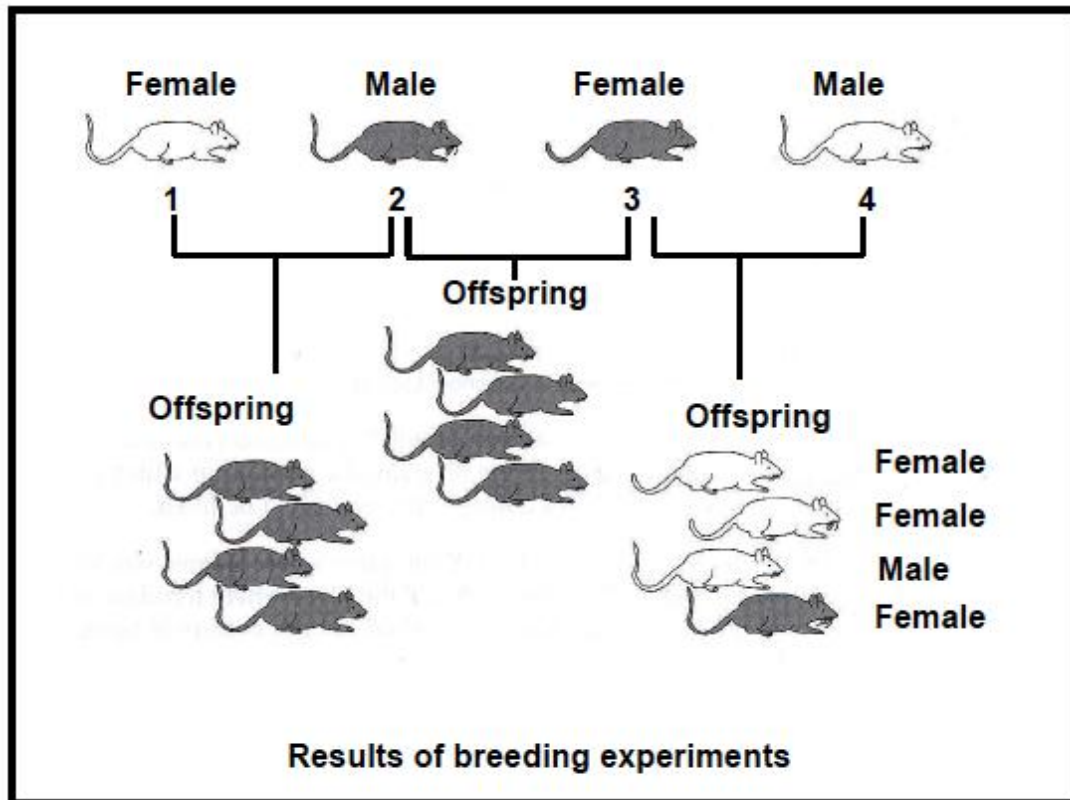


- 3.1. How many members of the family have free earlobes? (1)
- 3.2. What proportion of offspring in the fourth generation are females with attached earlobes? (2)
- 3.3. If the genotype of person A is FF, what will be the genotype of person B? (2)
- 3.4. Give a reason for your answer to QUESTION 3.3. (2)
- 3.5. Persons E and F are twins. Were they produced from a single fertilised egg cell or from two separately fertilised egg cells? (1)
- 3.6. Explain your answer to QUESTION 3.5. (2)
- 3.7. Is it possible for individuals C and D to have a child with free earlobes? (1)
- 3.8. Explain your answer to QUESTION 3.7. (2)

[13]

**QUESTION 4: 6 minutes***(Taken from DoE Feb/March 2009 Paper 1)*

Study the diagram below that shows some breeding experiments on rats. A single pair of alleles showing complete dominance controls coat colour (white or grey) in these mice.



- 4.1. State which sex chromosomes would be present in the gametes of parent mouse 2 and mouse 3, respectively. (2)
- 4.2. If mice 3 and 4 had a second set of offspring, what is the percentage chance that the first mouse born would be female? (1)
- 4.3. Which of the parent mice (1, 2, 3 or 4) is likely to be homozygous dominant for coat colour? (1)
- 4.4. State why mouse 3 can only be heterozygous for coat colour. (2)
- [6]

<b>SECTION B: ADDITIONAL CONTENT NOTES</b>
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**1. MENDEL'S FIRST LAW: THE LAW OF DOMINANCE AND SEGREGATION**

**Background:** Gregor Mendel (1822–1884) was an Austrian Augustinian monk who enjoyed experimenting with plants and investigating the outcome. He is known as the first **biogeneticist**. He studied the characteristics of garden peas grown in the monastery garden and recorded his findings. The laws he wrote are based on these findings and are used by geneticists today.

The Law of Dominance and Segregation: when two individuals with **contrasting homozygous** (pure-bred) characteristics are crossed, the individuals of the **F<sub>1</sub> hybrid generation** will all resemble the parent possessing the dominant characteristic. This law shows the principles of dominance and recessiveness using the characteristic of height. Pea plants either grow tall (TT or Tt) or are short plants (tt). Mendel crossed the pure bred homozygous tall and homozygous short varieties to prove his theories.

**P<sub>1</sub> TT x tt - Meiosis**

<b>Gametes</b>	<b>t</b>	<b>t</b>
<b>T</b>	Tt	Tt
<b>T</b>	Tt	Tt

**Fertilisation**

**F<sub>1</sub>**

**Genotype:** 4:4 Tt heterozygous offspring      **Phenotype:** 100% Tall

**(Note that the F<sub>1</sub> offspring show characteristics from both parents.)**

The plants of the F<sub>1</sub> grow and mature. When they are ready to reproduce, they produce gametes for tallness (T) and shortness (t) because the **gametes segregate** (T + T + t + t) during meiosis. One half of the gametes will contain the characteristic of one of the parents - for tallness and the other half will contain the characteristic of the other parent plant - for shortness. The characteristic for shortness is the **recessive** characteristic and it will appear in the second cross offspring called the **F<sub>2</sub> generation**.

P<sub>2</sub> Tt x Tt - Meiosis

Gametes	T	t
T	TT	Tt
t	Tt	tt

### Fertilisation

F<sub>2</sub> **Genotype:** 1:4 Homozygous Tall, 2:4 Heterozygous Tall, 1:4 Homozygous short  
(1 TT : 2 Tt : 1 tt)

**Phenotype:** 75% tall {1 homozygous tall + 2 heterozygous tall}  
25% short {1 homozygous short}



**Learner Note:** Mendel's First Law is a MONOHYBRID cross because only ONE characteristic is focused on per generation. The more examples you do, the better you will be. Check the mark so that you don't forget to write information and loose marks for this. You need to understand that the punnet square shows the **possible** combination of the gametes. Check the notes given in Session 12 about the terms each time the term is mentioned in an monohybrid cross and check that you remember, e.g. homozygous – Homo = same and zygoous = 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.

## 2. Sex Determination

In humans, the **somatic cells** are diploid and contain 23 pairs of chromosomes in each nucleus of which:

- 22 pairs of autosomes
- 1 pair of sex chromosomes: females - **XX** sex chromosomes and males - **XY** sex chromosomes

Gametes are formed by **gametogenesis** in the **ovaries** and **testes**. The egg cell (female gamete) can only ever contain one X chromosome, but half the sperm cells will have X and half will have Y chromosomes. When fertilisation occurs, there is a 50 % chance that the zygote is male and a 50 % chance that the zygote is female:





$P_1$ **Meiosis**

<b>gametes</b>	<b>X</b>	<b>X</b>
<b>X</b>	XX	XX
<b>Y</b>	XY	XY

**Fertilisation** $F_1$ **Genotype:** X X 2:4 X Y 2:4**Phenotype:** 50% males and 50% females**Sex-linked genetic diseases:**

**Haemophilia** (the inability of the blood to clot) and colour blindness are disorders that are sex-linked characteristics. The alleles of the genes for these disorders are **recessive** and located on the **X chromosome** of the female. Females are generally 'carriers' of the gene, with the gene masked by the normal allele gene.

Males have only ONE X chromosome, so if the gene is present, there is NO masking allele and they will inherit and display the trait.

**Sex-linked genetic crosses:****H = normal (dominant)****h = haemophilia (recessive)**Carrier female:  $X^H X^h$  where H = normal (dominant) and h = haemophilia (recessive)Normal male:  $X^H Y$  there is no 'arm' on the chromosome to carry the allele $P_1$  $X^H Y \times X^H X^h$  - Meiosis

<b>Gametes</b>	<b><math>X^H</math></b>	<b><math>X^h</math></b>
<b><math>X^H</math></b>	$X^H X^H$	$X^H X^h$
<b>Y</b>	$X^H Y$	$X^h Y$

**Fertilisation** $F_1$ **Genotype:** 1:4  $X^H X^H$ , 1:4  $X^H Y$ , 1:4  $X^H X^h$ , 1:4  $X^h Y$ **Phenotype:** 25% normal female ( $X^H X^H$ )25% normal male ( $X^H Y$ )25% carrier female ( $X^H X^h$ )25% male with haemophilia ( $X^h Y$ )

### 3. Blood Group Inheritance

Each human has blood flowing through their blood vessels. Blood is determined by **THREE alleles** and not two as for all other characteristics and traits. The fact that there are three possible genes is termed **multiple alleles**. Specific proteins that are present on the surface of the red blood cells determine the blood type. Protein A and protein B are coded by **alleles A and B**. If no protein A or B is present, then these cells will be coded by the **allele O**. Any two of these alleles (genes A, B or O) will occur in combination in an individual. The alleles A and B are **co-dominant** (both dominate equally) over O, which is **recessive**.

The **rhesus factor** plays a further role in determining blood type. **Rh-positive** - the presence of the rhesus **antigen** on the surface of the red blood cell. **Rh-negative** – the **absence of the antigen**. Blood groups are classified by the gene and also the rhesus factor, e.g.: A<sup>+</sup> or A<sup>-</sup>. **Rh-negative** individuals have the ability to produce an antibody called **anti-Rh** as part of the immune response when their blood comes into contact with Rh-positive blood. The rhesus system can cause complications during blood transfusions, pregnancy and birth **Pregnancy**: if a Rh-negative mother carries an Rh-positive baby, the mother will produce **antibodies**. The antibodies react with the antigens present in the baby's blood and a condition called **haemolysis** will occur (breaking down of red blood cells) so baby has **fewer red blood cells** and less **oxygen carrying capacity**. The baby will look blue at birth = called a 'blue baby'. The first pregnancy is not really a problem, as the mother does not produce enough antibodies to cause real harm to the foetus. With following pregnancies, the mother will produce more antibodies. Medical Science has developed a substance that is injected into the mother to remove Rh-positive foetal cells before they stimulate the production of more antibodies to protect the next Rh-positive foetus.

#### Types of blood groups:

Phenotype	Genotype
A	AA
A	AO
B	BB
B	BO
AB	AB
O	OO

#### **Did you know?**

*An organism's full set of genes on all its chromosomes is known as its genome. There are certain methods that scientists have used since the late 1980s to find the sequence of base pairs of the DNA, and to identify the position of genes on human chromosomes. This is called the **Human Genome Project**.*

**SECTION C: HOMEWORK EXERCISES***(Questions taken and adapted from Study & Master Biology Grade 11)***QUESTION 1**

In guinea-pigs, the gene for black coat is dominant to the gene for white. Two heterozygous black guinea-pigs are crossed.

- 1.1. By means of a diagram, show the genotypic results that would be expected in the  $F^1$  generation. (7)
  - 1.2. One of the white  $F^1$  offspring was crossed with its black parent. By means of a diagram show the expected  $F^1$  genotypic results of this new cross. (6)
- [13]

**QUESTION 2**

In horses black coat colour (B) is dominant over white (b). A white mare mates twice with the same black stallion. She produces a white foal on the first occasion and a black foal on the second occasion. Use the letters B and b as indicated above and write down the genotypes of:

- 2.1. the mare and stallion (2)
  - 2.2. the first and second foal (4)
- [6]

**SECTION D: SOLUTIONS AND HINTS TO SECTION A****QUESTION 1**

- 1.1. Mr. Xhosa -  $I^A I^B$  ✓  
 Wife -  $I^B I^B$  or  $I^B I^O$  ✓  
 $F^1$  is  $I^A I^B$  or  $I^B I^B$  or  $I^B I^O$  or  $I^A I^O$ . ✓✓✓✓  
 Baby 'A' is the only possible blood group ✓. Baby 'O' is not a possibility  
***(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.)***
- 1.2. Mr. Mbundwini -  $I^A I^A$  or  $I^A I^O$  ✓✓  
 Wife – Not given, but assume she is recessive ✓. Therefore baby 'O' is the possible blood group ✓ as 'O' cannot be the result of Mr. Xhosa and his wife ✓.  
**(Each tick = ½ mark)** [6]

**QUESTION 2**

2.1. BB = brown eyes bb = blue eyes - since both 3 and 4 have brown eyes, 2 will be BB.

1 = bb ✓

2 = BB ✓

3 = Bb ✓

4 = Bb ✓

5 = bb ✓

(5)

2.2. Brown = BB Blue = bb

**P<sup>1</sup>** ✓ **Bb x Bb** - **Meiosis** ✓

Gametes	B	b	✓
B	BB	Bb	✓
b	Bb	bb	✓
✓			

**Fertilisation** ✓

**F<sup>1</sup>** ✓

**Genotype:** 1:4 Homozygous brown BB, 2:4 Heterozygous brown – Bb ✓ ,  
1:4 Homozygous blue – bb ✓

**Phenotype:** 75% brown ✓ {1 homozygous brown + 2 heterozygous brown}  
25% blue ✓ {1 homozygous blue} (**Each tick = 1/2 mark**)

(6)

**[11]****QUESTION 3**

3.1 8 (1)

3.2 25 ✓ % ✓ (2)

3.3 Ff (2)

3.4 Individual B would have **one dominant gene** since he/she has free earlobes ✓ and the other gene **must be recessive** since they were able to produce offspring with attached earlobes/the recessive characteristic ✓ (2)

3.5 Two separate (1)

3.6 One is male and the other is female ✓  
Identical twins are identical in every respect ✓ /from the same sex (2)

3.7 No (1)

3.8 Since C and D have attached earlobes ✓ they have only recessive genes ✓ and can, therefore, have no dominant gene/gene for free earlobes to pass to their offspring ✓ .  
**(Any 2)** (2)

**[13]**

**QUESTION 4**4.1 Mouse 2 – XY  $\square$   $\sqrt$ Mouse 3 – XX  $\square$   $\sqrt$ 

(2)

4.2 50%  $\square$   $\sqrt$ 

(1)

4.3 Mouse 2  $\sqrt$ 

(1)

4.4 A cross between mouse 3 and mouse 4  $\square$   $\sqrt$  produced offspring with white  $\sqrt$  /recessive coat colour and white colour will only show up if both parents have at least one recessive gene  $\square$   $\sqrt$

**(Any 2)** (2)**[6]**

**TOPIC 2: MENDEL'S 2<sup>ND</sup> LAW AND GENETIC PROBLEMS**

**Learner Note:** Mendel's Second Law can be difficult to grasp. Ensure that you are comfortable with monohybrid crosses before you begin to do dihybrid crosses. A dihybrid cross works with TWO characteristic at a time (di = two). The process is the same as for a monohybrid crosses, it is just that the two characteristics are passed to the offspring in **different possible combinations**. If one characteristic has 4 possible outcomes, then two characteristics will be  $4 \times 4 = 16$  possible outcomes/combinations. Learn each of the steps carefully as they are in the additional content notes. Once you are comfortable with this, then try the homework questions. You **MUST** know Mendel's pea plant crosses. Follow each step and look at **WHY** each step is done. Refer to the additional content notes.

**SECTION A: TYPICAL EXAM QUESTIONS**

**QUESTION 1: 25 minutes** *(Taken and adapted from Bios Grade 11 – 2002)*

In guinea-pigs, black fur (B) is dominant over albino (b) and course hair ( R ) is dominant over smooth hair ( r ).

- 1.1. Supply the genotypes and phenotypes of a cross between homozygous black animal with course hair and an albino animal with smooth hair in the F1 generation. (10)
  - 1.2. Supply the genotypes and phenotypes of the F2 generation if two of the offspring from the F1 generation are crossed. (15)
  - 1.3. Explain Mendel's Law of Independent Assortment (4)
- [29]

**QUESTION 2: 13 minutes**

A woman with brown eyes and dark hair marries a man with blue eyes and blonde hair. All the children have dark hair, but half have blue eyes and the other half have brown eyes. Provide the genotypes of the parents and the children. Let (E) represent dominant brown eye colour and (e) recessive blue eye colour. Let (B) represent dominant brown hair colour and (b) recessive blonde hair colour. (Show all your workings in punnet squares).

[13]

<b>SECTION B: ADDITIONAL CONTENT NOTES</b>
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**MENDEL'S LAW OF INDEPENDENT ASSORTMENT**

You have learned that each trait is controlled by **allele genes**, located on a separate pair of chromosomes. Mendel stated that different pairs of genes **segregate independently** of the members of other pairs, when two or more characteristics (traits) are involved in a dihybrid cross. This means that each characteristic separates on its own during meiosis.

For example: hair colour and eye colour are two characteristics. The following are possible examples of the combinations if B = brown hair, b = blonde hair, N = brown eye colour and n = blue eye colour:

<b>BB, NN</b>	– Homozygous brown hair, Homozygous brown eyes
<b>BB, Nn</b>	– Homozygous brown hair, Heterozygous brown eyes
<b>BB, nn</b>	– Homozygous brown hair, Homozygous blue eyes
<b>Bb, NN</b>	– Heterozygous brown hair, Homozygous brown eyes
<b>Bb, Nn</b>	– Heterozygous brown hair, Heterozygous brown eyes
<b>Bb, nn</b>	– Heterozygous brown hair, Homozygous blue eyes
<b>bb, NN</b>	– Homozygous blonde hair, Homozygous brown eyes
<b>bb, Nn</b>	– Homozygous blonde hair, Heterozygous brown eyes
<b>bb, nn</b>	– Homozygous blonde hair, Homozygous blue eyes

This means that each characteristic can combine with any number of other combinations. Remember that ONE characteristic presents FOUR possible combinations when fertilisation takes place between TWO parents.

Male parent = 2 allele genes and Female = 2 allele genes. During meiosis, **each gene** from the allele pair will **separate independently** in the male and the same will take place in the female. Mother (2) x Father (2) = 4

In a **dihybrid cross** (di = two) - **two parents** will each have **two characteristic** that are passed to their offspring. Each parent will therefore present **4 sets** of possibilities in the genotype. Mother (4) x Father (4) = 16 possible combinations of the genotype.

Mendel used peas to explain a dihybrid cross where two traits/characteristics were crossed. A genetic trait for a round seed versus a wrinkled seed will be **independent** of the combinations for a yellow versus green colour of the seeds. This means that seeds can be round and yellow, round and green, wrinkled and yellow or wrinkled and green – so, there will be 16 combinations.

**Dihybrid cross of homozygous parents**

R = round seeds (dominant)

r = wrinkled seeds (recessive)

Y = yellow seeds (dominant)

y = green seeds (recessive)

The parents are as follows:

**'Parent 1': RRYY** – homozygous round AND homozygous yellow and**'Parent 2': rryy** – homozygous wrinkled AND homozygous green**Step 1: RRYY x rryy** - we need to find the combination of gametes for each of the parents

<b>'Parent 1': RR x YY - Meiosis</b>		
<b>Gametes</b>	<b>R</b>	<b>R</b>
<b>Y</b>	RY	RY
<b>Y</b>	RY	RY

<b>'Parent 2': rr x yy - Meiosis</b>		
<b>Gametes</b>	<b>r</b>	<b>r</b>
<b>y</b>	ry	ry
<b>y</b>	ry	ry

**Step 2: The Dihybrid cross**

Now take the 4 combinations for 'parent 1' and the 4 combinations for 'parent 2'

**P<sub>1</sub>**

<b>Gametes</b>	<b>RY</b>	<b>RY</b>	<b>RY</b>	<b>RY</b>
<b>ry</b>	RrYy	RrYy	RrYy	RrYy
<b>ry</b>	RrYy	RrYy	RrYy	RrYy
<b>ry</b>	RrYy	RrYy	RrYy	RrYy
<b>ry</b>	RrYy	RrYy	RrYy	RrYy

**Fertilisation****F<sub>1</sub>****Genotype:** 16:16 Heterozygous RrYy**Phenotype:** 100% round and yellow**HINT:** Choose one letter as the letter to be written **first** in each case.Here we chose R. Always write the **capital letters** before the small letters so write RR or Rr or rr first and then the Y, either YY or Yy or yy.



Now if we cross these  $F_1$  seeds (offspring of the  $P_1$ ) we must follow **Step 1** again:

So, to find the  $P_2$  we need to find the combinations of :

'Parent 1':  $RrYy$  and

'Parent 2':  $RrYy$  (both parents are heterozygous round and heterozygous yellow)

$RrYy \times RrYy$  (to find the combination of gametes for each parent)

$Rr \times Yy$ - Meiosis			$Rr \times Yy$ - Meiosis		
Gametes	R	r	Gametes	R	r
Y	RY	rY	Y	RY	rY
y	Ry	ry	y	Ry	ry

$P_2$

Gametes	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

**Fertilisation**

$F_2$

**Genotype:** 1:16 RRYY, 2:16 RRYy, 1:16 RRyy, 2:16RrYY, 4:16 RrYy, 2:16 Rryy, 1:16 rrYY, 2:16 rrYy and 1:16 rryy

**Phenotype:** 9 round and yellow, 3 round and green, 3 wrinkled and yellow, 1 wrinkled and green. (There will always be a total of 16 combinations in a dihybrid cross)

### SECTION C: HOMEWORK

**QUESTION 1:** 30 minutes (Taken and adapted from Bios Grade 11 – 2002)

In a particular pigeon type, it was found that red eye colour ( R ) is dominant over black eye colour ( r ), while grey tail feathers ( G ) is dominant over white tail feathers ( g ).

Use punnett squares to show the genotype and phenotype of the offspring that would result from the following crosses:

1.1.  $GgRr \times GgRr$  (15)

1.2.  $GgRr \times GgRR$  (14)

[29]

**SECTION D: SOLUTIONS AND HINTS TO SECTION A**

**QUESTION 1**

1.1. **Dihybrid cross of homozygous parents:**

B = black fur (dominant)                      b = albino (recessive)

R = course hair (dominant) r = smooth hair (recessive)

**Note: Each  $\checkmark$   
=  $\frac{1}{2}$  mark**

The parents are as follows:

‘Parent 1’: **BBRR** – homozygous black AND homozygous course hair and

‘Parent 2’: **bbrr** – homozygous albino AND homozygous smooth hair

**Step 1: (find the separate gene combinations)**

**BBRR x bbrr**  $\checkmark\checkmark$

‘Parent 1’: **BB x RR - Meiosis**  $\checkmark$

‘Parent 2’: **bb x rr - Meiosis**  $\checkmark$

<b>Gametes</b> $\checkmark$	<b>B</b>	<b>B</b>	$\checkmark$
<b>R</b>	BR	BR	
<b>R</b>	BR	BR	
$\checkmark$			

<b>Gametes</b> $\checkmark$	<b>b</b>	<b>b</b>	$\checkmark$
<b>r</b>	br	br	
<b>r</b>	br	br	
$\checkmark$			

**Step 2:**

**(Cross all 16 gene combinations. Remember to choose one letter that you will always write first and write capital letter for the same characteristic in front of the lower case letter.)**

**P<sub>1</sub>**  $\checkmark$

<b>Gametes</b> $\checkmark$	<b>BR</b>	<b>BR</b>	<b>BR</b>	<b>BR</b>	$\checkmark$
<b>br</b>	BbRr	BbRr	BbRr	BbRr	
<b>br</b>	BbRr	BbRr	BbRr	BbRr	
<b>br</b>	BbRr	BbRr	BbRr	BbRr	
<b>br</b>	BbRr	BbRr	BbRr	BbRr	
$\checkmark$					

**Fertilisation**  $\checkmark$

**F<sub>1</sub>**  $\checkmark$  **Genotype:** 16:16  $\checkmark$  Heterozygous BbRr  $\checkmark$  **Phenotype:** 100%  $\checkmark$  black with course hair  $\checkmark$  (10)

1.2. F<sub>2</sub> generation: **BbRr x BbRr** ✓✓

<b>Bb x Rr - Meiosis</b> ✓				<b>Bb x Rr - Meiosis</b> ✓			
<b>Gametes</b> ✓	<b>B</b>	<b>b</b>	✓	<b>Gametes</b> ✓	<b>B</b>	<b>b</b>	✓
<b>R</b>	BR	bR		<b>R</b>	BR	bR	
<b>r</b>	Br	br		<b>r</b>	Br	br	
✓				✓			

P<sub>2</sub> ✓

<b>Gametes</b> ✓	<b>BR</b>	<b>Br</b>	<b>bR</b>	<b>br</b>	✓
<b>BR</b>	BBRR	BBRr	BbRR	BbRr	✓
<b>Br</b>	BBRr	BBrr	BbRr	Bbrr	
<b>bR</b>	BbRR	BbRr	bbRR	bbRr	
<b>br</b>	BbRr	Bbrr	bbRr	bbrr	
✓✓					

**Fertilisation** ✓

F<sub>2</sub> ✓

**Genotype:** 1:16 BBRR ✓; 2:16 BBRr ✓; 1:16 BBrr ✓; 2:16 BbRR ✓; 4:16 BbRr ✓;  
2:16 Bbrr ✓; 1:16 bbRR ✓; 2:16 bbRr ✓ and 1:16 bbrr ✓

**Phenotype:** 9 black with course hair ✓; 3 black with smooth hair ✓; 3 albino with  
course hair ✓; 1 albino with smooth hair ✓ (15)

1.3. Mendel's Law of independent assortment states that different ✓ pairs of genes  
**segregate independently** ✓ of the members of other pairs ✓, when two or more  
characteristics ✓ (traits) are involved in a dihybrid cross. (**You must know this  
definition well**) (4)

[29]

## QUESTION 2

2. B = brown hair colour (dominant) b = blonde hair colour (recessive)  
E = brown eye colour (dominant) e = blue eye colour (recessive)

**Note: Each ✓  
= ½ mark**

**Female parent: BB Ee** – homozygous brown hair AND heterozygous brown eyes

**Male parent: bb ee** – homozygous blonde hair AND homozygous blue eyes

**Step 1: (find the separate gene combinations)**

**BBEe x bbee** ✓✓

**Mother: BB x Ee - Meiosis** ✓

**Father: bb x ee - Meiosis** ✓

<b>Gametes</b> ✓	<b>B</b>	<b>B</b>	✓
<b>E</b>	BE	BE	
<b>e</b>	Be	Be	
✓			

<b>Gametes</b> ✓	<b>b</b>	<b>b</b>	✓
<b>e</b>	be	be	
<b>e</b>	be	be	
✓			

**Step 2:**

*(Cross all 16 gene combinations. Remember to choose one letter that you will always write first and write capital letter for the same characteristic in front of the lower case letter)*

**P<sub>1</sub>** ✓

<b>Gametes</b> ✓	<b>BE</b>	<b>BE</b>	<b>Be</b>	<b>Be</b>	✓✓
<b>be</b>	BbEe	BbEe	Bbee	Bbee	
<b>be</b>	BbEe	BbEe	Bbee	Bbee	
<b>be</b>	BbEe	BbEe	Bbee	Bbee	
<b>be</b>	BbEe	BbEe	Bbee	Bbee	
✓✓					

**Fertilisation** ✓

**F<sub>1</sub>** ✓ **Genotype:** 8:16 ✓ BbEe ✓ ; 8:16 ✓ Bbee ✓

**Phenotype:** 50% ✓ brown hair and brown eyes ✓  
50% ✓ brown hair and blue eyes ✓

**[13]**

## SESSION %%

**TOPIC: ANIMAL RESPONSE TO THE ENVIRONMENT: ENDOCRINE SYSTEM AND HOMEOSTASIS**

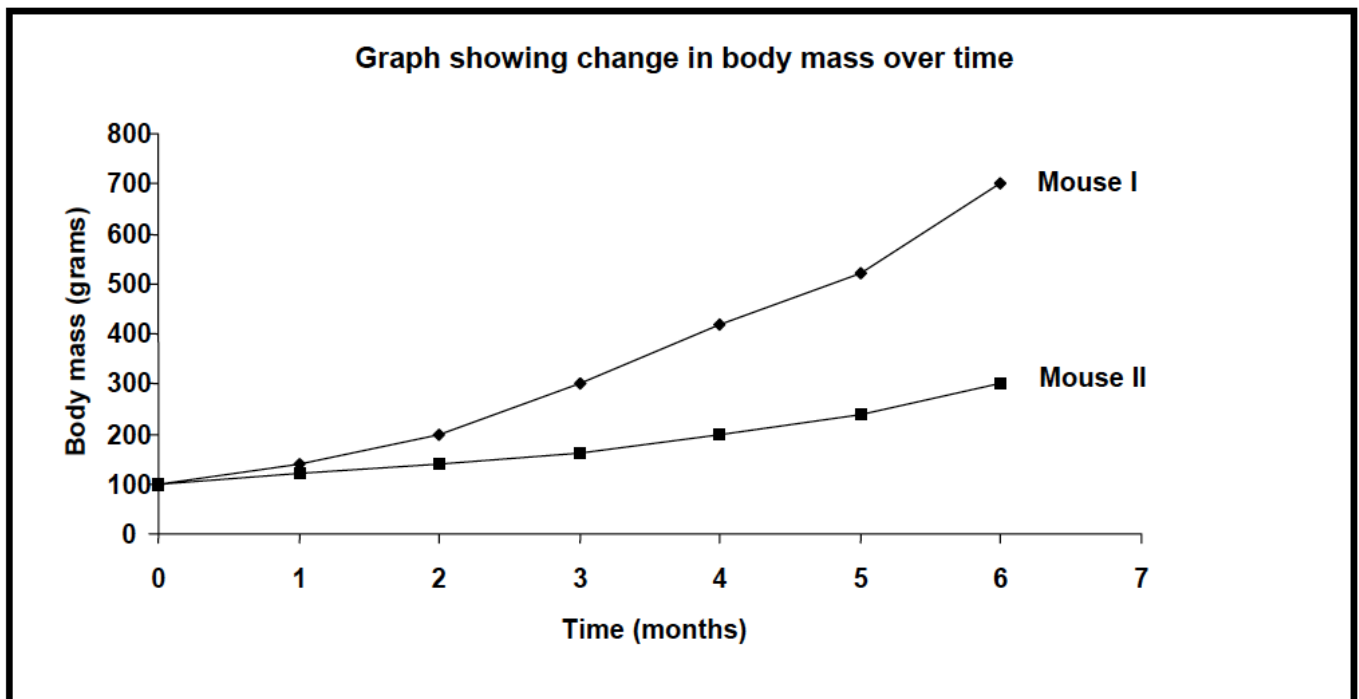
**Learner Note:** Knowledge and application: Please ensure that you know what chemical co-ordination is; the differences between the endocrine and exocrine glands; basic characteristics of hormones; location and function of hormones produced by the endocrine glands; what negative feedback is; causes, prevention and symptoms of some diseases like diabetes, thyroid disorders, growth disorders and infertility; structure versus function of the different parts of the skin; how to regulate body temperature.

**SECTION A: TYPICAL EXAM QUESTIONS**

**QUESTION 1:** 14 minutes 14 marks (Taken from DoE May/June 2008 Paper 2)

The graph below shows the change in mass of two young mice from the same litter (born from the same parents) over time. One of the two mice was injected with a substance secreted by an endocrine gland. Study the graph and answer the questions that follow.

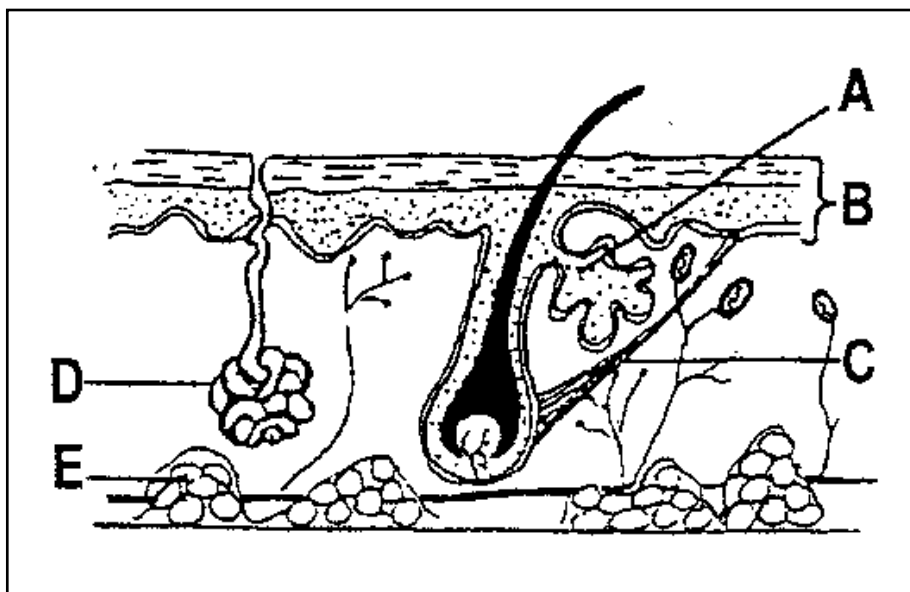
**HINT:** For any graph question – study the graph first. Look at the heading and take note of what is being graphed. Then read the dependent (Y-axis) and independent (X-axis) variables carefully. Always use a ruler when you read data off a graph as this will ensure that you are accurate. Use a pencil to draw lines across the points that you are required to get information from. Where the lines cross will be the point that you are looking at. It will also show you what the readings are at the X and Y axis without error. Graphs are the easiest way to score marks. Make sure that you practise your graphing skills.





**QUESTION 4: 10 minutes 17 marks** (Taken from Bios Best 2007 HG)

Study the diagram of the human skin and answer the questions that follow:



- 4.1. Provide labels for structures A, B, D and E. (4)
  - 4.2. State ONE function of C and D respectively. (4)
  - 4.3. Describe the role played by the skin in regulating blood temperature on a cold day. (9)
- [17]

**QUESTION 5: 15 minutes 25 marks** (Taken from Bios Best 2007 HG)

Read the passage and then answer the questions that follow:

The way blood sugar level is controlled in the mammalian body is an example of a hormonally influenced control mechanism. A number of organs are involved in maintaining glucose at a relatively constant level in the blood. These include the liver, the pancreas, the adrenal glands and the hypothalamus.

Glucose molecules from the small intestine are absorbed into the blood and are transported to the liver. To keep the level of blood sugar constant, the liver releases small amounts of glucose into blood vessels, which run from the liver to the heart via the vena cava.

The pancreas is part of a three-part control system. The presence of glucose in the blood stimulates certain cells in the pancreas to secrete insulin. The major effect of insulin is to lower the amount of glucose in the blood.

A three-part control system "tells" the liver how much glucose should be released into the blood. Glucose molecules in the blood also act on the hypothalamus. An increase in the glucose content of the blood stimulates the hypothalamus to send inhibitory messages to the liver. On the other hand, should the glucose level drop below normal, the liver receives a signal to release more glucose.

A third mechanism helped to regulate glucose levels during strenuous exercise. As the body uses large amounts of glucose, the carbon dioxide level in the blood increases to a very high level. The liver cannot release glucose as fast as it is broken down. The hypothalamus now becomes active. It stimulates the adrenal glands to secrete adrenalin. Adrenalin acts on the liver cells, the result being an increase in the blood sugar level.

- 
- 5.1. Define the term hormones and homeostasis. (4 x 2) (8)
- 5.2. Which cells in the pancreas secrete insulin? (2)
- 5.3. What stimulates the three centres of the three-part control system? (1)
- 5.4. Explain why the interaction between the liver and the hypothalamus is referred to as a negative feedback system. (9)
- 5.5. Apart from the hormones named in the passage, there is one other hormone that plays a major role in the utilisation of glucose. Name this hormone and describe its role in glucose metabolism. (5)
- [25]

## SECTION B: ADDITIONAL CONTENT NOTES

### The Endocrine System

The endocrine system is responsible for **chemical coordination** and regulates activities that take place inside the body. The endocrine glands produce **hormones**. Hormones are **chemical messengers**. All endocrine glands are **ductless** which means that the hormones are secreted directly into the **blood**. Each gland has a **rich supply of blood** to transport the hormones to the **target organs**. Hormones generally consist of **proteins** and **fats**, but some (like the sex hormones) consist of fats only. Hormones control the activities of a target organ, but **do not** themselves perform the activity. Hormones work together as a **system** where they either stimulate or inhibit organs. Processes are **regulated** to ensure normal growth, development and functioning of all the systems in a **coordinated manner**. This **coordination** ensures that tissue fluid, nutrients, blood pressure, temperature, blood glucose levels, osmoregulation, temperature regulation, oxygen and carbon dioxide levels and salt concentrations (electrolytes) are controlled. The body is able to function at an optimum level.



## Endocrine glands and hormonal secretions

Hormone	Gland	Location	Function	Effect of under- and oversecretion
<b>Growth hormone (somatotrophin)</b>	<b>Anterior lobe</b> of the pituitary gland	Base of the brain and attached to the hypothalamus	For growth, repair and replacement of cells	<b>Oversecretion:</b> Children – giantism Adults – acromegaly <b>Undersecretion:</b> Children – pituitary dwarf Adults – premature senility
<b>Follicle stimulating hormone (FSH)</b>	<b>Anterior lobe</b> of the pituitary gland	Base of the brain and attached to the hypothalamus	<b>In males:</b> stimulates spermatogenesis <b>In females:</b> stimulates the development of the follicle for process of ovulation	No over- or undersecretion effects
<b>Luteinising hormone (LH)</b>	<b>Anterior lobe</b> of the pituitary gland	Base of the brain and attached to the hypothalamus	<b>In males:</b> stimulates the synthesis of the hormone testosterone by the Leydig cells in the testes <b>In females:</b> LH stimulates the release of the secondary oocyte from the Graafian follicle and then the development into the corpus luteum	No over- or undersecretion effects
<b>Thyroid-stimulating hormone (TSH)</b>	<b>Anterior lobe</b> of the pituitary gland	Base of the brain and attached to the hypothalamus	Stimulates the production of thyroxin by the thyroid gland	<b>Oversecretion:</b> goitre <b>Undersecretion:</b> lack of production of thyroxin – thyroid gland is under stimulated
<b>Antidiuretic hormone (ADH)</b>	Neurosecretory cells of the <b>hypothalamus</b> (ADH is stored in the posterior lobe of the pituitary gland)	In the centre of the brain	Regulates osmoregulation in the kidneys (in the distal convoluted tubules and the collecting tubules)	<b>Oversecretion:</b> water retention and swelling (oedema) <b>Undersecretion:</b> dehydration

Hormone	Gland	Location	Function	Effect of under- and oversecretion
<b>Thyroxin</b>	Thyroid gland	Below the larynx in the neck region	<ul style="list-style-type: none"> <li>Regulates the basal metabolic rate of the cells in the body</li> <li>Affects growth and functioning of the heart and the nervous system</li> <li>Stimulates growth and differentiation of tissue in a foetus and in children</li> <li>Regulates the body temperature when stimulated by the hypothalamus</li> </ul>	<b>Oversecretion:</b> goitre <b>Undersecretion:</b> Children – cretinism Adults – myxedema
<b>Aldosterone</b>	Cortex of the adrenal gland	Above the kidney	Helps the uptake of sodium ions in the loop of Henle in the kidneys	<b>Oversecretion:</b> oedema (water retention) <b>Undersecretion:</b> Addison's disease
<b>Adrenalin (fight-and-flight hormone)</b>	Medulla of the adrenal gland	Above the kidney	Prepares the body to deal with stress: <ul style="list-style-type: none"> <li>Increase in heartbeat rate</li> <li>Increase in breathing rate</li> <li>Increase in blood pressure</li> <li>Increase in muscle tone</li> <li>Increase in blood sugar levels</li> <li>Decrease in blood supply to the skin and digestive system</li> <li>Causes pupils to dilate</li> </ul>	There are no known over- or undersecretion effects. The sympathetic and parasympathetic nervous system controls the release of adrenalin
<b>Glucagon</b>	Islets of Langerhans – alpha cells	Endocrine cells of the pancreas	Controls the increase in the blood sugar level by causing the conversion of glycogen to glucose	No over- or undersecretion effects

Hormone	Gland	Location	Function	Effect of under- and oversecretion
<b>Insulin</b>	Islets of Langerhans – beta cells	Endocrine cells of the pancreas	<ul style="list-style-type: none"> <li>• Controls blood sugar by causing the conversion of glucose into glycogen</li> <li>• Inhibits the functioning of glucagon</li> </ul>	<b>Oversecretion:</b> obesity <b>Undersecretion:</b> diabetes
<b>Testosterone</b>	Gonads: testes	Leydig cells in the testes of males located in the scrotum at the bottom of the pelvis	<ul style="list-style-type: none"> <li>• Testosterone is responsible for the secondary sexual characteristics in males like a deeper voice, pubic hair, hair on face</li> <li>• Necessary for the normal development of sperm</li> <li>• Activates genes in the cells of Sertoli to promote the differentiation of the spermatogonia</li> </ul>	<b>Oversecretion:</b> aggression. In females, it results in secondary sexual characteristics similar to that in males <b>Undersecretion:</b> lack of secondary sexual characteristics and lack of healthy sperm production
<b>Oestrogen</b>	Gonads: ovaries	Located in the lower abdominal region with each ovary located within the pelvic bones (in line with the ball-and-socket joints of the femurs)	<ul style="list-style-type: none"> <li>• Oestrogen promotes the development of the secondary sexual characteristics in females like breasts, the thickening of the endometrium (uterus) and the female body shape</li> <li>• Necessary for the process of ovulation</li> <li>• Oestrogen <b>inhibits</b> the secretion of FSH by the anterior pituitary gland so that only one follicle is produced during ovulation</li> <li>• High oestrogen levels will trigger the secretion of <b>luteinising hormone (LH)</b></li> </ul>	<b>Oversecretion:</b> may cause cancer <b>Undersecretion:</b> menstruation cycle is affected, ovulation may be prevented leading to infertility, onset of menopause may occur

Hormone	Gland	Location	Function	Effect of under- and oversecretion
<b>Progesterone</b>	Gonads: ovaries	Located in the lower abdominal region with each ovary located within the pelvic bones (in line with the ball-and-socket joints of the femurs)	<ul style="list-style-type: none"> <li>• Progesterone prepares the endometrium of the uterus for implantation once fertilisation of the egg cell has occurred</li> <li>• Necessary for the production of the mucus plug to prevent sperm or other substances from entering the uterus during pregnancy</li> <li>• Decrease in progesterone levels causes menstruation</li> <li>• Progesterone improves memory and cognitive ability</li> </ul>	<b>Undersecretion:</b> during pregnancy, will cause a spontaneous miscarriage
<b>Prolactin</b>	Anterior lobe of the pituitary gland	Base of the brain and attached to the hypothalamus	<ul style="list-style-type: none"> <li>• Stimulates the mammary glands to produce milk</li> <li>• Counteracts the effect of dopamine which is responsible for sexual arousal</li> </ul>	<b>Oversecretion:</b> can cause impotence and loss of libido

### Disorders of the endocrine system

**Diabetes:** Insulin is produced by the beta cells of the Islets of Langerhans, in the pancreas. This hormone is **released when blood sugar level is HIGH** and the person is said to be **hyperglycaemic**. Insulin regulates the blood sugar content by promoting the absorption of glucose into the cells. It causes the oxidation of glucose at tissue level and increases liver function by causing the liver (the target organ) to convert glucose to glycogen so that it can be stored. Insulin also causes the increase in the rate of fat and protein synthesis by the tissue of the body. It inhibits the conversion of glycogen to glucose by the liver and muscles cells.

Diabetes is a disease where the body does not produce enough insulin. This causes glucose to accumulate in the blood and muscle tissue. If too much glucose is present in the blood, the cells become metabolically more active and produce more energy. High levels of glucose in the tissue fluid, causes osmosis from the cells to the tissue fluid causing cells to die.

**Symptoms** of diabetes are: excessive urination, excessive thirst, weight loss, slow and delayed healing of sores and wounds, oedema, increased blood pressure and possible cardio-vascular, capillary and renal damage. Diabetes cannot be cured, but can be controlled with a strict diet and insulin injections to regulate blood sugar levels.

### Thyroid disorders:

The Thyroid releases thyroxin in response to the Thyroid Stimulating Hormone (TSH) released by the pituitary gland. **Iodine** is a micro-nutrient needed for the production of thyroxin. Thyroxin regulates the basal metabolic rate of the cells in the body, affects growth and functioning of the heart and the nervous system, stimulates growth and differentiation of tissue in a foetus and in children, regulates the body temperature when stimulated by the hypothalamus and regulates the functioning of the digestive system.

- **Hyperthyroidism:** overactivity of the thyroid and increase in the level of thyroxin in the blood. This will cause an increased basal metabolic rate, weight loss, increased nervousness, excitability and irritability, Exophthalmia (bulging eyes), Endemic goitre: an iodine deficiency may result in the swelling of the thyroid gland  
Hyperthyroidism can be treated by the surgical removal of most of the excess gland or by administering radioactive iodine.
- **Hypothyroidism:** underactivity of the thyroid and a decrease in the level of thyroxin in the blood. This could be due to a lack of TSH production by the anterior pituitary gland, an iodine deficiency in the diet or failure of the enzyme system involved in thyroxin production. This will cause Cretinism – a deficiency of thyroxin at birth that will lead to mental retardation and poor growth in children, and Myoedema – a deficiency of thyroxin in adults which leads to loss of physical and mental vigour, increased weight, retention of fluids, puffiness in the face and eyelids, the swelling of the tongue, the roughening and thickening of the skin, and hair loss from head and eyebrows. All the symptoms can be eliminated and the condition treated by taking thyroxin tablets.

### Growth disorders

The anterior pituitary gland secretes human growth hormone (hGH)/somatotrophin, which regulates body growth and development, particularly growth in the long bones and muscles.

- **Oversecretion of hGH**
  - in children will result in **giantism**. This is excessive growth of the bones of an individual resulting in growth of between 7 and 8 feet (2.5m).
  - in adults will result in **acromegaly**. This is the increase in the thickness of the bones and an increase in growth of the soft tissue causing an enlargement of the hands, feet, skull, nose and jawbone.
- **Undersecretion of hGH**
  - in children will result in midgets (not dwarfism which is a genetic syndrome). Individuals grow in proportion but very slowly, resulting in 'little people'. Should this condition be diagnosed early before maturing, external growth hormone (steroids) can be used to treat the condition.
  - in adults will result in premature senility, where the individual will age physically at an alarming rate, internal organs will weaken, there is memory loss, confusion and dementia. (a person of 40 years of age will physically look like a person of 80 years of age)

## Infertility

**Female hormones:** Oestrogen and progesterone are secreted by the ovaries. Oestrogen controls the secondary sexual development, prepares the uterus for the implantation of a fertilised egg and its development. Progesterone/ Progesterone controls the changes in the uterus after ovulation and also in pregnancy.

- **Undersecretion:**

- of oestrogen may cause sterility and personality changes
  - of progesterone may result in miscarriage and failure to ovulate
- Undersecretion can be corrected with hormone therapy.

**Male hormones:** Testosterone is secreted by the testes. Testosterone controls the secondary sex development in males and the functioning of the male organs.

- **Undersecretion**

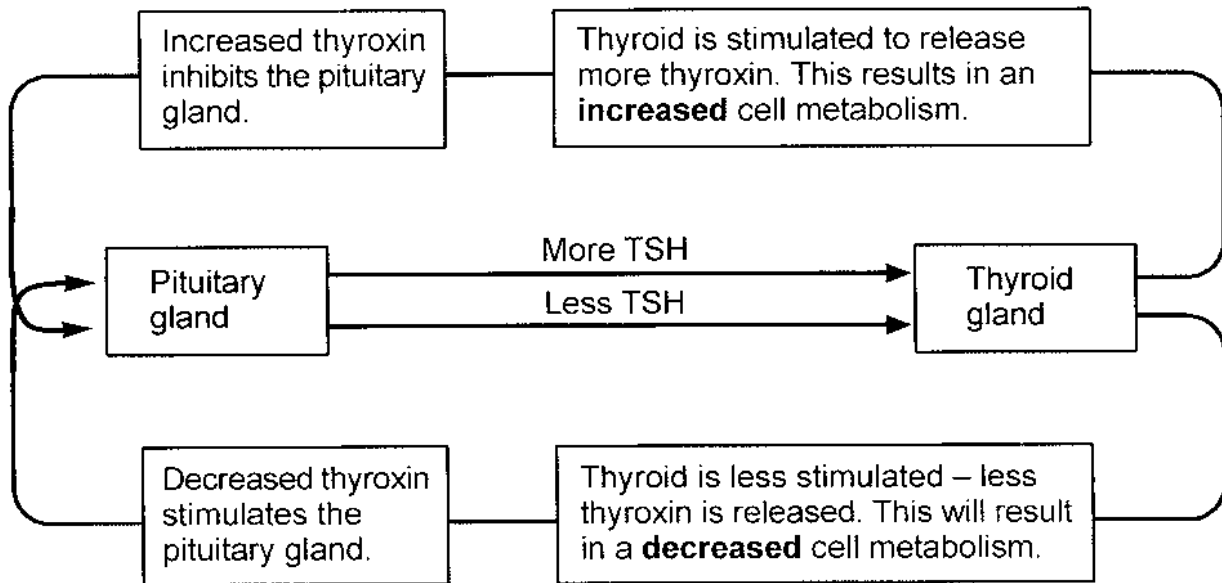
- physical underdevelopment
- psychological disturbances
- low sperm count
- abnormal sperm (sperm have two heads or tails)

## Homeostasis

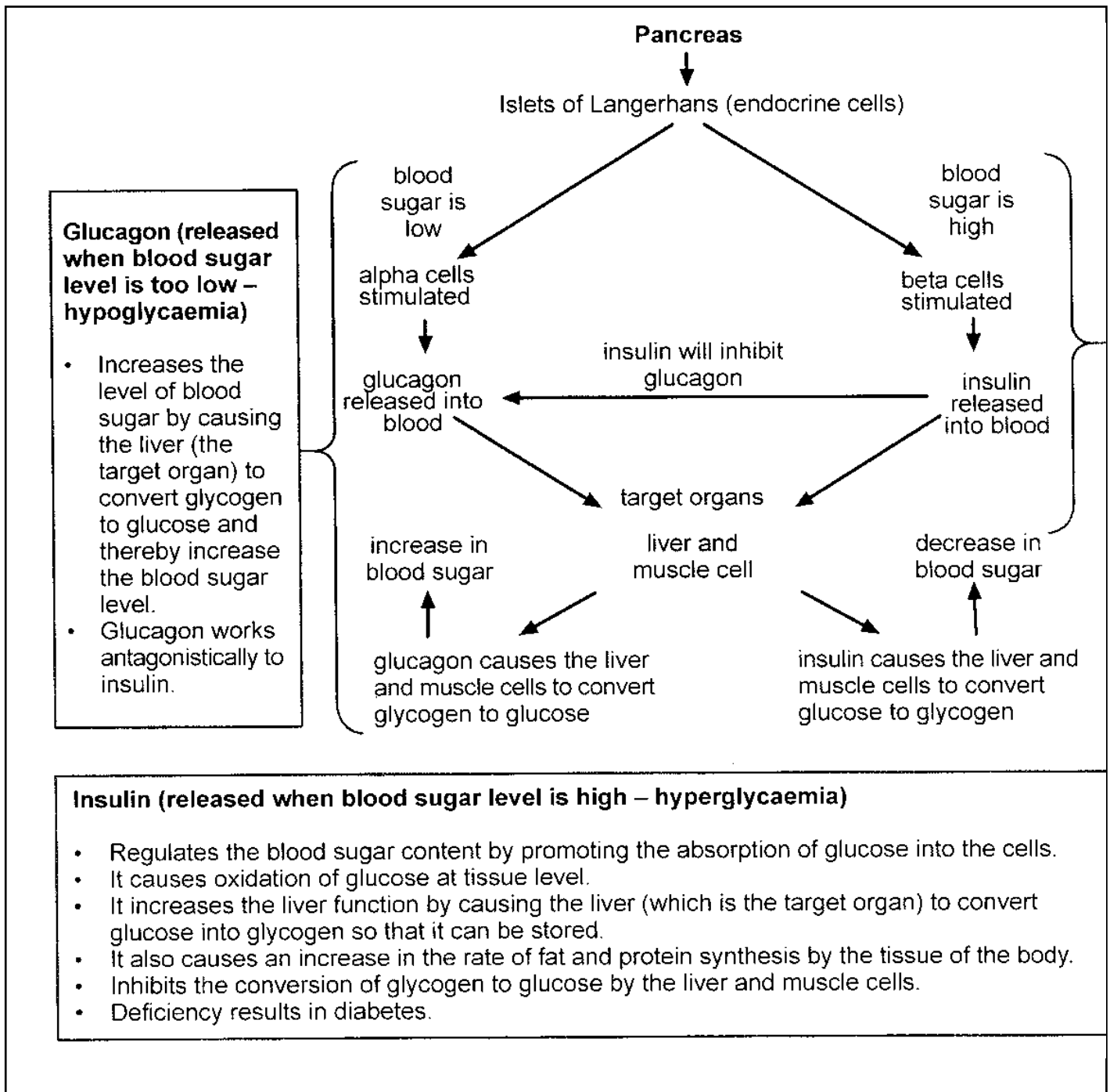
Homeostasis is the **maintenance of a relatively constant internal environment** by automatic control mechanisms. Cells will function normally, regardless of the external environment. The nervous system **controls** all the other systems in the body either directly or indirectly.

Homeostasis of the endocrine system occurs through the **negative feedback mechanism**. Feedback systems are important because they ensure that all the systems are interrelated and work together. When there is an increase from normal, a corrective mechanism will cause it to decrease and vice versa. This ensures that a **balance** is maintained within the body. There are three negative feedback mechanisms that are very important:

- the regulation of thyroxin
- the regulation of blood sugar levels
- the regulation of oestrogen and progesterone

**NEGATIVE FEEDBACK CONTROL – REGULATION OF THYROXIN IN THE BLOOD**

## NEGATIVE FEEDBACK CONTROL – BLOOD SUGAR LEVELS





### Differences between the endocrine system and the nervous system

Endocrine system	Nervous system
<ol style="list-style-type: none"> <li>1. Made up of glands</li> <li>2. Produces hormones</li> <li>3. Hormones transported by the blood</li> <li>4. Effects are slower and more general</li> <li>5. Hormones control long-term changes (e.g. growth)</li> </ol>	<ol style="list-style-type: none"> <li>1. Made up of nerves</li> <li>2. Produces nerve impulses</li> <li>3. Impulses transmitted along the nerves</li> <li>4. Effects are very quick and very specific</li> <li>5. Nerve impulses control short-term changes (e.g. sneezing, lifting your arm)</li> </ol>

### Thermoregulation

Body temperature must be **kept constant** in homoeothermic organisms like birds and mammals. Optimal body temperature in humans is between 36,6 °C and 37 °C.

Remember that all cells, antibodies, enzymes and most hormones are made of protein, and proteins are sensitive to temperature and pH. If the temperature is too high, the proteins will denature and be unable to function. If the temperature is too low, the proteins will become inactive. So, the human body must work hard to keep the temperature constant. The hypothalamus stimulates various systems to regulate the body temperature. When the body is hot, the hypothalamus will stimulate the pituitary to release more ADH and less thyroxin. When the body is cold, the opposite will take place.

Hot day	Cold day
<p>The body gets hot:</p> <ul style="list-style-type: none"> <li>• You need <b>more</b> water in the blood to make <b>more</b> sweat to cool you down</li> <li>• <b>More</b> ADH is released by the pituitary gland to keep <b>more</b> water in the blood</li> <li>• Blood vessels near the surface of the skin <b>dilate</b> (vasodilation), so <b>more</b> blood reaches the sweat glands</li> <li>• <b>More</b> sweat evaporates, cooling the skin and the blood in the vessels near the surface of the skin</li> <li>• This means that you will produce <b>more</b> concentrated urine (less water in the urine)</li> <li>• The hairs in the skin <b>lie flat</b> so no heat is trapped between the skin and the hairs</li> <li>• The pituitary gland <b>inhibits</b> the thyroid so <b>less thyroxin</b> is released causing a <b>decrease</b> in cell metabolism, so <b>less energy</b> is released – body cools down</li> </ul>	<p>The body gets cold:</p> <ul style="list-style-type: none"> <li>• You need <b>less</b> water in the blood as you <b>do not</b> need to produce sweat</li> <li>• <b>Less</b> ADH is released by the pituitary gland to keep <b>less</b> water in the blood</li> <li>• Blood vessels near the surface of the skin <b>constrict</b> (vasoconstriction), so <b>less</b> blood reaches the sweat glands</li> <li>• <b>No</b> sweat evaporates, so there is no cooling of the skin and the blood in the surface vessels</li> <li>• This means that you will produce <b>less</b> concentrated urine (dilute urine)</li> <li>• The hairs in the skin are <b>pulled upright</b> by the erector muscles to trap warm air (goose bumps)</li> <li>• The pituitary gland <b>stimulates</b> the thyroid so <b>more thyroxin</b> is released, causing an <b>increase</b> in cell metabolism. <b>More energy</b> is released and causes shivering – body warms up</li> </ul>

**Hypothermia** : occurs when the body is exposed to cold and the **internal mechanisms** cannot keep the **internal core body temperature** constant. Hypothermia takes place in three phases.

- **Phase 1:** Body temperature drops 1–2 °C below normal. The skin forms goose bumps to trap warm air between the hair and the skin. Shivering follows and the hands and feet become numb as blood vessels to the skin constrict.
- **Phase 2:** Body temperature drops 2–4 °C below normal. Violent shivering and beginning of loss of muscle coordination. Movements are slow and person becomes confused. Blood vessels to skin constrict further, channelling warmth to the vital organs. Skin becomes pale; lips, fingers, toes and ears take on a blue colour.
- **Phase 3:** Body temperature drops to between 30 °C and 32 °C. The person loses the ability to think, speaks incoherently, movement and muscle coordination will become very poor. Breathing rate will slow down but heart rate will increase. Major organs will fail and clinical death will result.

**Hyperthermia:** occurs when the body become **too hot** and is unable to cool the **internal core temperature** down sufficiently. This results in **dehydration**, heat stroke and heat exhaustion.

### Thermoregulation – animal adaptations

Various species of animals have behavioural, physical and physiological adaptations to deal with thermoregulation:

- Panting - dogs
- Insulation - fat layers, trapped air under the fur of their bodies, birds ruffle their feathers
- Body size – larger body loses more heat – larger surface area
- Heat exchange mechanism – dolphins
- Body orientation - reptiles
- Water conservation - kangaroo rat has a highly water-efficient metabolism
- Behaviour patterns
  - Hibernation – winter sleep when it is very cold
  - Aestivation - ‘summer sleep’ and is similar to hibernation when it is very hot and dry
  - Burrowing - hide in burrows in the soil
  - Nocturnal behaviour – come out at night only
  - Avoidance behaviour – lizards and hot desert sand – only two limbs touch at a time

**SECTION C: HOMEWORK****QUESTION 1**

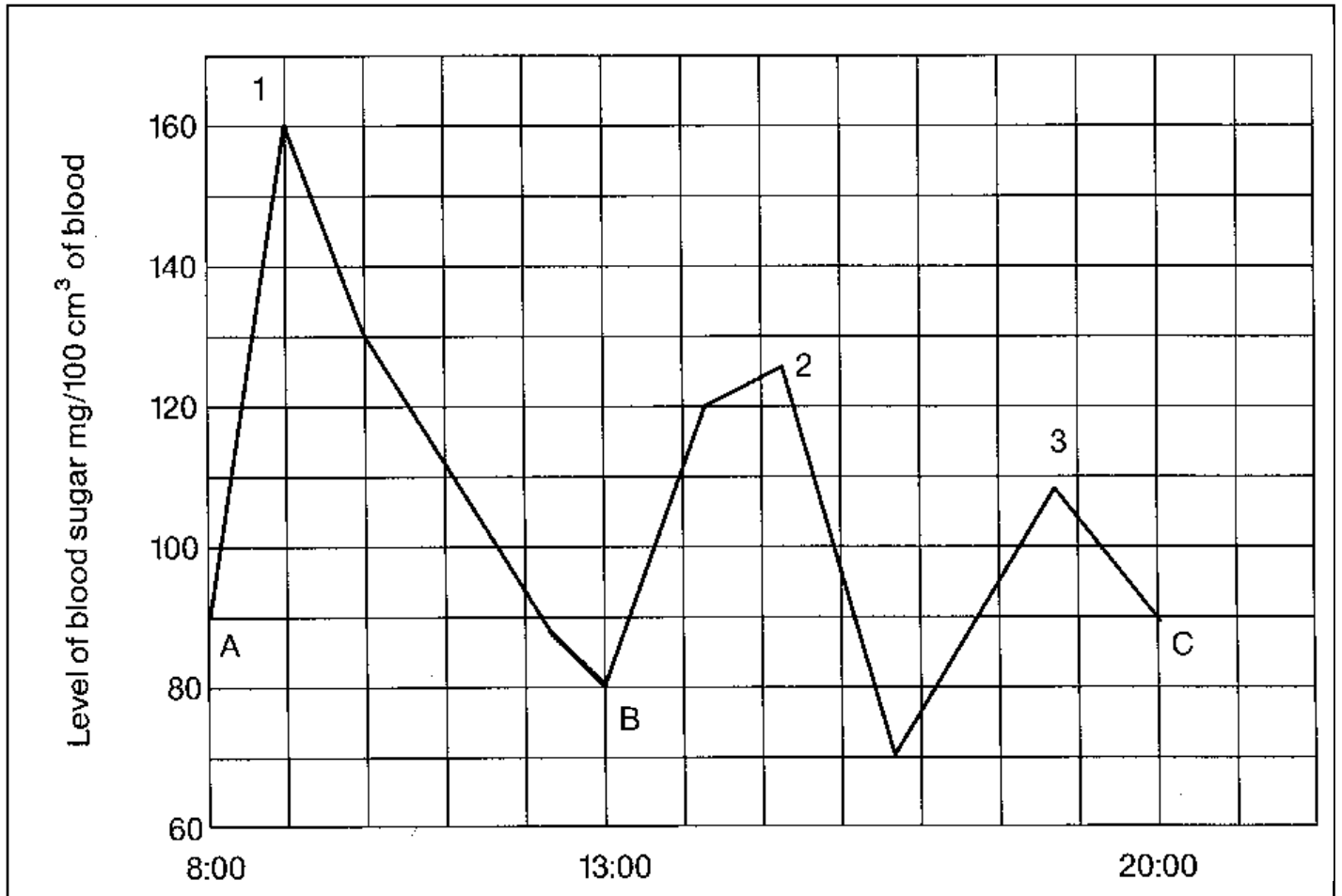
Write down the correct biological term for each of the following descriptions.

1. The secretions that are produced in small quantities by endocrine glands.
2. The endocrine gland which controls the hormonal secretions of most of the other endocrine glands.
3. The endocrine gland that can be regarded as the 'master gland' in the human body.
4. A system of all the hormone-secreting glands in the human body.
5. An enlarged thyroid gland, resulting from an iron deficiency.
6. The pair of endocrine glands located just above each kidney.
7. A disease in which the hormonal control of blood glucose is defective because of an absolute or relative deficiency of insulin.
8. The hormone secretion of the islets of Langerhans which lowers the glucose level in the blood.
9. The system informing the human body of changes in its internal and external environment.
10. The endocrine gland which secretes adrenalin.
11. The autonomic response to a stimulus which is not under conscious control.
12. The secretion of the thyroid gland.
13. The hormone that stimulates the secretion of the hormone of the thyroid gland.
14. The hormone that prepares the body for an emergency.
15. An aspect of the control system in which the ultimate effects of the system will counteract the original stimulus.

[15]

**QUESTION 2**

The graph below shows the level of the blood sugar of a healthy person during a 12 hour period. Study the graph and answer the questions that follow:



- 2.1. At what time of day is the level of the blood sugar:
- the lowest and (1)
  - the highest? (1)
- 2.2. What is the level of the blood sugar at:
- 10:00 and (1)
  - 16:00? (1)
- 2.3. During which hour is the level of the blood sugar:
- 140mg/100 cm<sup>3</sup>, and (1)
  - 75mg/100 cm<sup>3</sup> blood? (1)
- 2.4. During which hour was the rate of increase in the level of blood sugar:
- the greatest and (1)
  - the smallest? (1)
- 2.5. What occurred at point **A** and **B** on the graph to cause the subsequent changes in the levels of the blood sugar? (4)

LIFE SCIENCES	GRADE 12	SESSION %%	(LEARNER NOTES)
2.6.	At points 1, 2 and 3 on the graph, the concentration of blood sugar drops.		
	a) Which hormone is responsible for the decrease in concentration?		(1)
	b) Where in the body is this hormone produced?		(2)
2.7.	There is an increase in the concentration of the blood sugar between 17:00 and 18:00.		
	a) Which hormone is responsible for this increase?		(1)
	b) Where in the human body is this hormone produced?		(2)
	c) Briefly describe the role played by this hormone mentioned in Question 2.7 b) in decreasing the level of the blood sugar.		(4)
2.8.	At 20:00 the person got a fright/was frightened.		
	a) What do you expect to happen to the level of the blood sugar at point C?		(1)
	b) Which hormone is involved now?		(1)
	c) Where in the human body is this hormone produced?		(1)
	d) What are the effects of the hormone mentioned in Question 2.8 c) on the person's body in times of fright?		(5)
	e) Which part of the autonomic nervous system produced similar effects on the human body to those mentioned in Question 2.8 d)?		(1)
2.9.	What is the pathological condition called when the sugar level in the blood is abnormally high? What would the normal level be?		(2)
			[33]

### SECTION D: SOLUTIONS AND HINTS TO SECTION A

#### QUESTION 1

1.1	Hypophysis / Pituitary	(1)
1.2	Mouse I	(1)
1.3	- Growth hormone (GH) / Somatotrophic hormone (STH)	(1)
1.4	- For the same time period - it showed a greater increase in mass	(2)
1.5	Fourth / 4th ✓ month	(2)
1.6	(a) - Lower temperature ✓ for either of the mice - will cause more food to be oxidised / increased metabolic rate ✓ and less food will be available for growth (b) - Less food ✓ available for either of the mice - will lead to a smaller body mass since food is used ✓ for growth	(2)
	<b>OR</b>	
	- Different food types ✓ - contribute differently to the growth ✓ of an organism	(2)
1.7	- One of the target organs of GH is bone ✓ - Bone length cannot be increased ✓ in adult mice - because bone growth has stopped ✓	
	<b>OR</b>	
	- One of the target organs of GH is bone ✓ adult mice don't need ✓ to grow any more ✓	(3)
		[14]

**QUESTION 2**

- 2.1
- More blood needed by muscles ✓
  - to provide sufficient oxygen ✓
  - and glucose ✓
  - for oxidation to provide energy. ✓
  - The arterioles in the skin are thus constricted ✓
  - causing less blood to reach the skin ✓

**(Mark Any 4) (4)****OR**

- Nervous ✓
- therefore, adrenalin produced ✓
- therefore less blood to skin ✓
- more blood to muscles ✓

**(Mark Any 4) (4)**

- 2.2
- Increased respiration/oxidation ✓ during race
  - generates a large amount of heat. ✓
  - The arterioles in the skin dilate ✓
  - to allow more blood with heat ✓ to reach the skin
  - so that excess heat can be lost to the environment ✓

**(Mark Any 4) (4)**  
**[8]****QUESTION 3**

3.1.

	Spectator	Athlete
(a)	Contracted ✓	Relaxed ✓
(b)	More ✓	Less ✓
(c)	Less ✓	More ✓

**(6) + TABLE = (1) (7)**

- 3.2
- Athlete sweats more ✓
  - to use more body heat ✓ to evaporate sweat
  - in order to cool down the body/lower the body temperature ✓

**OR**

- Spectator sweats less ✓
- therefore, less body ✓ heat used to evaporate sweat
- because he is less active/his body temperature is not very high ✓

**(3)**

- 3.3
- Radiation ✓
  - Convection ✓
  - Evaporation ✓
  - Urination ✓
  - Defecation ✓
  - Expiration / Breathing ✓

**(Mark first 3 answers only) (3)****[13]**

**QUESTION 4**

- 4.1. A = oil gland / sebaceous gland  
 B = epidermis  
 D = sweat gland  
 E = subcutaneous fat tissue / adipose tissue (4 x 1) (4)
- 4.2. C = erector muscle: when the erector muscle contract, ✓ it pulls the hair up  
 to a more vertical position ✓ to trap warm air (2)  
 D = the sweat gland: secrete sweat ✓ to cool the body by evaporation ✓ (2)
- 4.3. The body gets cold:
- **Less** water is needed in the blood ✓ because you do not need to produce sweat
  - **Less** ADH is released by the pituitary gland ✓ to keep **less** water in the blood ✓
  - Blood vessels near the surface of the skin **constrict** (vasoconstriction), ✓ so **less** blood reaches the sweat glands ✓
  - Sweat glands produce less sweat ✓
  - **No** sweat evaporates, so there is no cooling of the skin and the blood in the surface vessels ✓
  - This means that **less** concentrated urine (dilute urine) is produced ✓
  - The hairs in the skin are **pulled upright** by the erector muscles to trap warm air ✓
- (9)  
**[17]**

**QUESTION 5**

- 5.1 **Hormones:** are organic chemical messenger, ✓ that are secreted by ductless ✓ endocrine glands and carried by the blood ✓ to a target organ. ✓  
**Homeostasis:** is the maintenance ✓ of a relatively constant ✓ internal environment for normal tissue functioning, ✓ controlled by the autonomic nervous system. ✓ (8)
- 5.2. Beta cells ✓ of the Islets of Langerhans in the pancreas (1)
- 5.3. the presence of glucose in the blood / blood glucose level. ✓ (1)
- 5.4.
- There is a negative feedback mechanism ✓ between the liver and the hypothalamus.
  - When the blood glucose level is low, ✓ the hypothalamus stimulates the liver ✓ to convert glycogen to glucose ✓ to increase the blood glucose level. ✓
  - When the blood glucose level is high, ✓ the impulses from the hypothalamus will be limited, ✓ causing the liver to decrease the conversion of glycogen to glucose, ✓ resulting in a decrease in the blood glucose level. ✓ (9)
  - Thyroxin regulates the basal metabolic rate of a person. ✓ With increased thyroxin secretion, the basal metabolic rate is increased. ✓
  - Thyroxin stimulates the use of oxygen and glucose for respiration ✓
  - Thyroxin accelerates cellular metabolism and therefore energy release (ATP and heat) ✓ Thyroxin stimulates protein synthesis which has an effect on growth in. ✓
  - Thyroxin promotes the breakdown and use of fats ✓
  - Thyroxin stimulates the excretion of cholesterol in bile, which lowers the blood cholesterol levels ✓
  - Increased levels of thyroxin will inhibit the pituitary gland from releasing TSH. ✓
- (Mark any 5 points) (5)  
**[25]**