PROTEIN SYNTHESIS AND DNA FINGERPRINTING

Learner Note: Please revise the structure of DNA and the functions of the 3 types of RNA before proceeding with Protein Synthesis. You must know that the resulting amino acid is based on the codon copied from the original DNA. Protein Synthesis is questioned regularly in examinations so you must understand the basics before moving on to the process of Protein Synthesis. When working through DNA fingerprinting, use a ruler when checking the DNA VNTR patterns. This way, you will very easily pick up where the markers are the same. Research Forensic Science and DNA fingerprinting , and consider Forensic Science as a possible career.

SECTION A: TYPICAL EXAM QUESTIONS - *40 minutes*

QUESTION 1: Multichoice – *10 minutes*

(When answering multichoice questionas 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 out. 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. DNA is found
   - A. in a gene
   - B. on a nucleus
   - C. on a membrane
   - D. on chromosomes

2. The building blocks of nucleic acids are called
   - A. nucleotides
   - B. nucleoli
   - C. nucleosides
   - D. nucleocodes

3. The sugar molecule present on RNA is
   - A. sucrose
   - B. ribose
   - C. deoxyribose
   - D. glucose

4. Which of the following is a complimemntary base pair normally present in the DNA molecule?

(REMEMBER THE RULE: G = C and A = T/U)

A. thymine and cytocine
B. thymine and guanine
C. cytocine and uracil
D. adenine and thymine

5. During protein synthesis the following steps take place in order:

A. DNA unwinds, transcription by mRNA, anticodons produced by tRNA, amino acids combine to form polypeptides
B. DNA unwinds, anticodons produced by mRNA, transcription by tRNA, amino acids combine to form polypeptides
C. DNA unwinds, transcription by mRNA, codons produced by tRNA, amino acids combine to form polypeptides
D. DNA unwinds, transcription by mRNA, anticodons produced by tRNA, amino acids are formed

6. Select the correct difference between a DNA and RNA:

(Tick all the correct points and cross all the points that are wrong, then select your answer)

	DNA	RNA
A	Ribose pentose sugar	Deoxyribose pentose sugar
B	Double helix strand	Single helix strand
C	Contains Thymine	Contains Uracil
D	Contains triplet bases	Contains only anticodons

7. Which part of the cell is the site of protein synthesis?

A. the chromosomes
B. the nucleus
C. the cytoplasm
D. the ribosomes

8. The monomers of proteins are:

A. nucleotides
B. triplets
C. anticodons
D. amino acids

9. In DNA fingerprinting, Scientists use a small number of sequences of DNA called
   A. mtDNA
   B. tRNA
   C. VNTR
   D. triplet bases

10. Which of the following are uses of DNA fingerprinting?
    1. matching paternity
    2. identification of a body
    3. detecting bacteria in pollutants
    4. keeping criminals in jail
    5. studying migration patterns

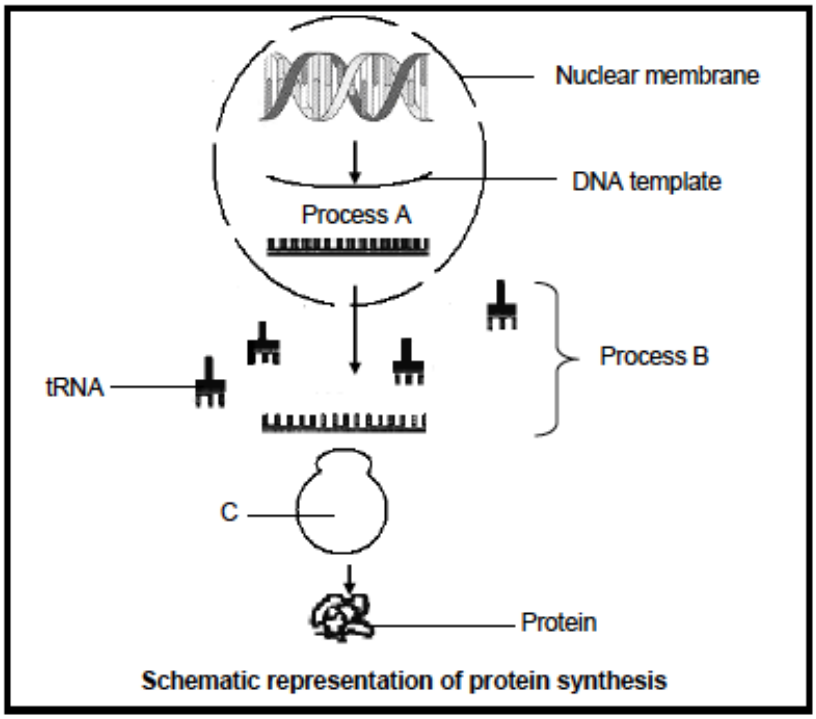
    A. 1, 2, 3, 5
    B. 1, 2, 3, 4
    C. 1, 2, 4, 5
    D. 2, 3, 4, 5 (10)

    (With this type of question, read through options 1 to 5 and tick those that are correct and apply to the question. Cross out those that do not. Select your answer from the ticked options)

QUESTION 2: – *20 minutes* *(Taken from DoE November 2008 paper 1)*

(Reminder: always complete the labels on a diagram before you move on to the questions)

The following diagram represents protein synthesis:



Schematic representation of protein synthesis

2.1 Name the following processes:
(a) A (1)
(b) B (1)

2.2 Name the organelle labelled C. (1)

2.3 Explain how the mRNA is made from the DNA template duringprocess A. (5)
(Reminder of transcription)

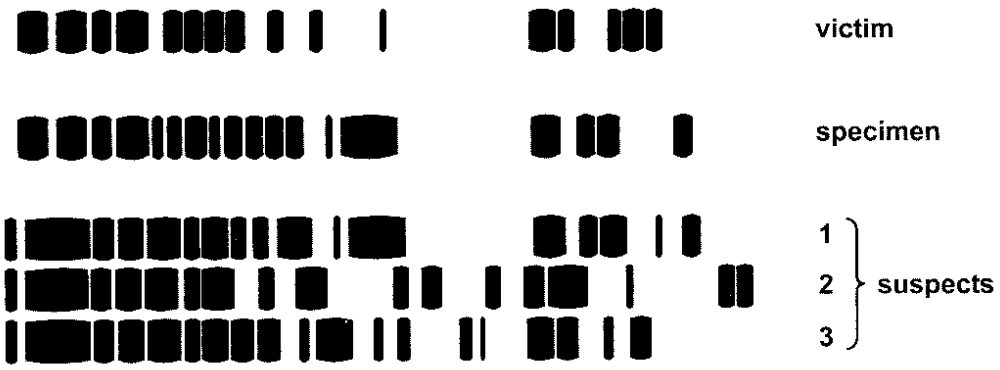
2.4 Processes A and B above can be summarized by the table below.
Write the numbers 1 – 3 and next to each number the nitrogenousbases that will complete the table. (6)
(Reminder: The DNA has a code. The mRNA is always the opposite complimentary bases to the DNA and the anticodons on the tRNA will always be the same as the DNA. Thymine on DNA is replaced with Uracil on the RNA)

Base sequence on DNA	Codon on mRNA	Anticodon on tRNA	Amino acid
CAA	1	2	Valine
3	GCA	CGU	Alanine

QUESTION 3: - *10 minutes*

The DNA in all cells of an individual is identical and the sequence of nucleotides in DNA is represented by a pattern of dark bands called the DNA fingerprint. Forensics involves comparing a crime suspect's genetic profile with the blood of a crime victim and with human biological material such as hair, blood, skin fragments or semen found at the scene of the crime. Forensic detectives have gathered evidence from a crime scene and have arrested three suspects. Using the genetic fingerprints below, state which of the suspects is the guilty party and provide a reason for your answer. (7)

(Reminder: Use a ruler to check for corresponding VNTR tracers – e.g. the 3rd tracer from the left is the same for the victum, the specimen and the suspects)



SECTION B: SOLUTIONS

QUESTION 1:

1. D
2. A
3. B
4. D
5. A
6. C
7. D
8. D
9. C
10. A (10)

2.1 (a) A - Transcription (1) ***(Ensure that you know the definitions and processes for A and B)***
(b) B – Translation(1)
2.2 C - Ribosome (1)
2.3 - Process is called transcription✓
− Free (RNA) nucleotides✓
− from the nucleoplasm✓
− arrange according to the base sequence✓ of the DNA template
− in a complementary✓ way
− A –U✓
− C –G✓
− Sugar-phosphate bonds form✓ between nucleotides to formrequired mRNA
− Process controlled by enzymes✓**max (5)**
2.4 1 –GUU✓✓
2 –CAA✓✓
3 –CGT✓✓**(3 x 2) = (6)**

(14)

3. Suspect 1 ✓✓

The VNTR ✓ of suspect 1 had 6 matches ✓ to the specimen ✓ found at the crime scene. Suspect 2 ✓ and

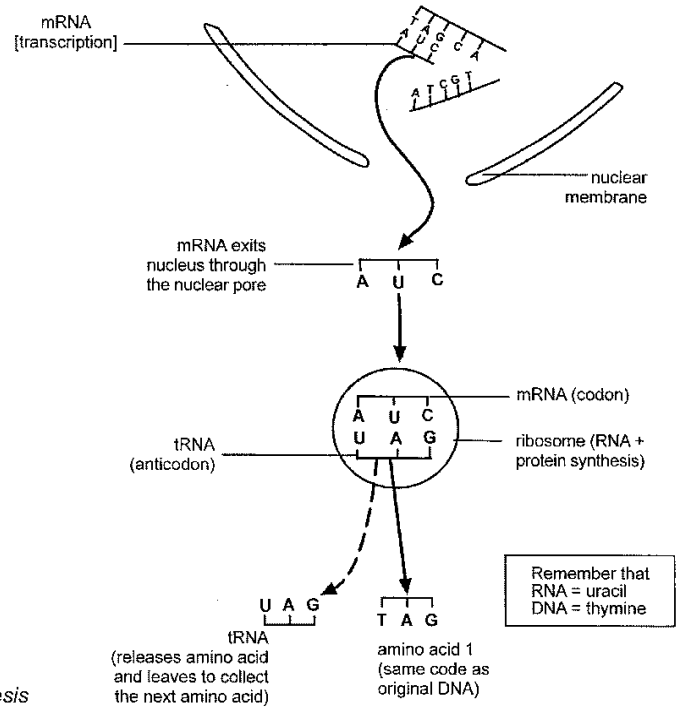
3 ✓ showed no matches (7)

SECTION C: ADDITIONAL CONTENT NOTES

1. PROTEIN SYNTHESIS

Proteins are macro molecules and always contain the elements **carbon, hydrogen, oxygen and nitrogen** (C, H, O, N). Some proteins contain sulphur and phosphorus as well. Proteins are made up of building blocks called amino acids (like bricks that are used to build a house. The amino acids are like the bricks, and the house is like the protein). Every living organism consists of proteins because all cells, hormones (except sex hormones), antibodies, blood and enzymes consist of proteins.

A protein is made up of 40 to a 1 000 amino acids, joined together in a variety of combinations. Amino acids are held together by **peptide bonds**to form peptide chains. The peptide chains join together to form proteins by a process called **polymerization**. This results because of protein synthesis to provide the sequence of the individual amino acids combination. Any small deviation or change will result in the protein losing the ability to function, or it can cause a **mutation**.



Protein synthesis

Schematic representation of Protein synthesis.

Protein synthesis - the process:

Step 1: Transcription (Remember that RNA contains uracil in place of thymine on the DNA)

- 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 (messenger RNA) strand in the nucleus. Each code on the DNA consists of three bases, called a triplet.
- Each mRNA strand consists of three bases called a codon, per DNA code triplet.
- So, the sequence of the bases in the DNA strand will determine the sequence of the bases in the mRNA – per codon.
- **This process of copying the triplet code onto the mRNA is called transcription.**
- If the sequence of the DNA triplet is CCC, TAA and CAG, then the mRNA will build codons of GGG (for the CCC), AUU (for the TAA) and GUC (for the CAG), which will be the complementary bases.
- 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.

Remember that RNA contains uracil in place of thymine on the DNA

Step 2: **tRNA has an anticodon** – it has the opposite bases to the codon. It picks 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; for example the mRNA codon of GGG will only accept the tRNA anticodon of CCC.

Remember that the CCC was originally on the DNA triplet.

Step 3: Translation: 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**.

The process of protein synthesis will continue until enough proteins have been produced. The mRNA breaks up into separate nucleotides and is stored in the nucleolus. The tRNA moves back into the cytoplasm, ready to be reused at a later stage. Each protein is formed specifically to the **genetic code** of the organism and is stored on the DNA in the nucleus of each cell. The cell selects the specific protein that must be produced by selecting the specific part of the DNA that will be copied as mRNA. Any change during this coding will result in a **mutation.**

An example of base triplet, codon and anticodon combinations:

Amino Acid	**Base triplet of DNA**	**Codon of mRNA**	**Anticodon of tRNA**
Alanine	CGA	GCU	CGA
Histidine	GTC	CAG	GUC
Valine	CAT	GUA	CAU
Serine	AGA	UCU	AGA

(Remember that **Uracil** is present in all RNA and replaces the **Thymine** on the DNA.)

Why is protein synthesis important?

- Process to produce **specific proteins**required for cells, antibodies, blood, enzymes and hormones
- Proteins are a **reserve energy source** in the body
- **Nucleoproteins** present in the chromosomes are important for cell division and heredity
- **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.

2. DNA fingerprinting

All living organisms have DNA with the same basic chemical structure. The differences are in the order of the nitrogenous base sequences.

> All humans have two eyes, a nose and a mouth yet everyone (except identical twins) looks different because each set has a different shape and structure that is individual to each person.

Each person's DNA is unique to that specific person. Scientists use **DNA markers**, by designing small pieces of DNA called **probes,** to establish a person's **DNA profile**. The probes bind to complementary DNA sequences and formulate a unique pattern for the individual. A selection of DNA sequences within the profile forms what is termed the **VNTR** pattern for that person. A sample of hair, blood, skin cells, mouth cells, tissue and body products are used to establish the VNTR. Forensic scientists are able to compare the DNA profiles to a sample that is provided from a crime scene. DNA profiling is very accurate and a criminal can be identified easily. However, there are many more uses of DNA fingerprinting, than merely to catch criminals.

- **To match paternity and maternity:** The first step in identifying a father would be **blood group** identification. Blood group testing can only prove that an individual is *not* the father because thousands of people have the same blood group.

  > If a man is Type O and the baby is also Type O, it does not prove that this is the baby's father because this is the most common blood group. There are many men with this blood group. If the man's blood group is Type AB, then the baby is definitely not his.

  When the child's blood group is the same as that of the possible father, DNA fingerprinting is used to prove whether an individual is in fact the father. Remember, an individual inherits his or her specific VNTRs from the parents.

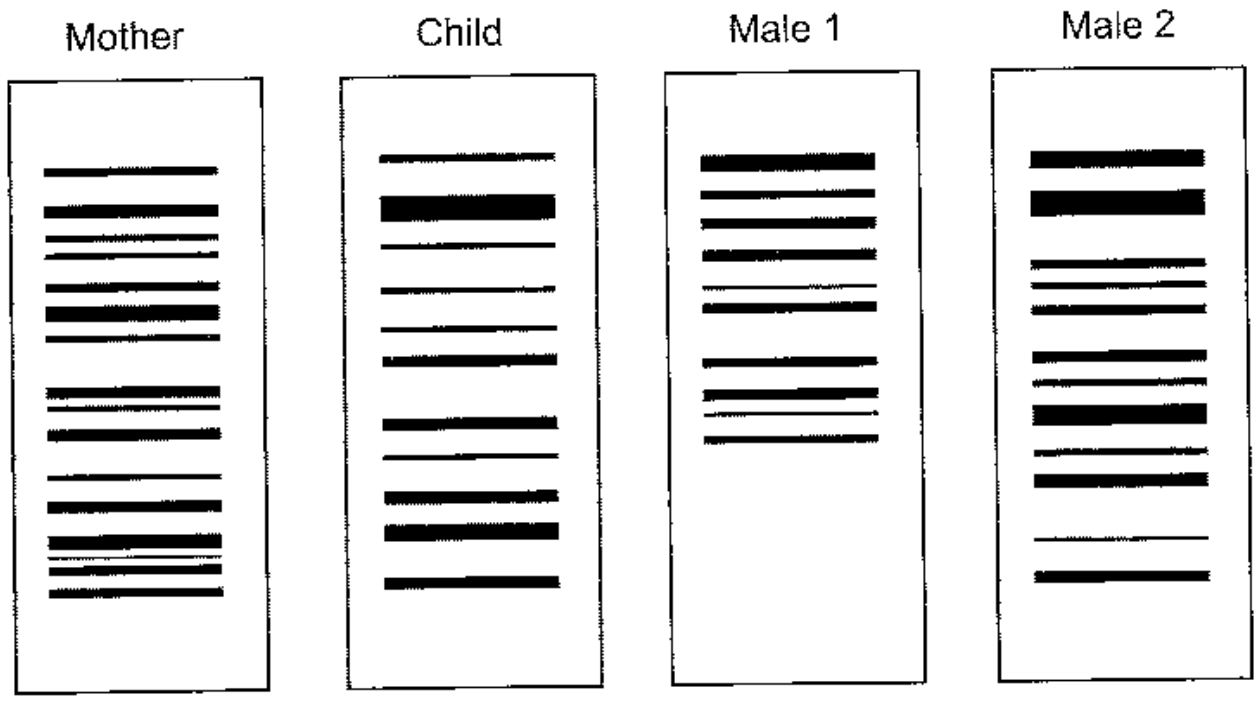
- **Criminal identification and forensics:** DNA samples of blood, hair, skin and seminal fluid that is found at the crime scene is collected for analysis. The VNTR of criminal suspects is compared to the samples. Usually, **four to five matches** must be found at various locations on the individual's genome (DNA profile) for it to be regarded as a match. VNTR is used to determine guilt or innocence and this evidence is regarded as irrefutable (cannot be doubted).

- **Identifying sexual offenders and rapists:** Forensic scientists use the Y chromosome that is found in the sperm, as the unique genetic marker. The VNTR is established and samples from the suspects is analysed and compared. The process is especially helpful when more than one male is involved as the process is able to identify each individually.
- **Identifying suitable organ donars:** The VNTR of the donor and recipient is compared to establish compatibility. There can never be a perfect match, so the donor with the closest match is used. The donor need not always be a relative. In some cases, an organ of a cadavor (deseased person) is a close enough match and the organ is transplanted.
- **Identifying a body:** Mitochondrial DNA analysis (mtDNA) is used to identify a body. A mother will have the same mtDNA as her child because the egg cell contains the mitochondria of each new embryo. The sperm contributes only nuclear DNA. The mtDNA profile is used to identify the remains of the corpse in missing person cases.

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.

1. A child is born out of wedlock. The mother needs to claim maintenance for the child, but does not know which one of two men is the father. She has had blood tests done, but both the men have the same blood type. Her next alternative is to do DNA fingerprinting. Both men provide samples and the VNTR of both is analysed. The results are below. Identify the real father and explain how you reached your conclusion. (3) **(Remember to use a ruler to check the corresponding VNTR codes)**



2. Describe the process of Protein sysnthesis. (16)

3. Provide THREE reasons why Protein synthesis is important. (3)

SECTION E: SOLUTIONS TO SESSION 9 HOMEWORK

1. (a) b – thymine✓
d – guanine✓
e – hydrogen bond✓ (3)
(b) c✓ , a✓, b✓ (3)
(c) To join two chains / helices✓ (1)
(d) mutation✓ (1)
(e) ultra-violet rays✓, x-rays✓ (2)
(f) DNA✓ – double helix✓ (2)

2. (a) RNA✓ (1)
(b) single chain✓
uracil present✓ (2)
(c) Bases do not pair✓ (1)
(d) ribose✓ (1)
(e) mRNA, tRNA, ✓ rRNA✓ (3)