



# X-Sheet 2

## Protein Synthesis and DNA Fingerprinting

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### Key Concepts:

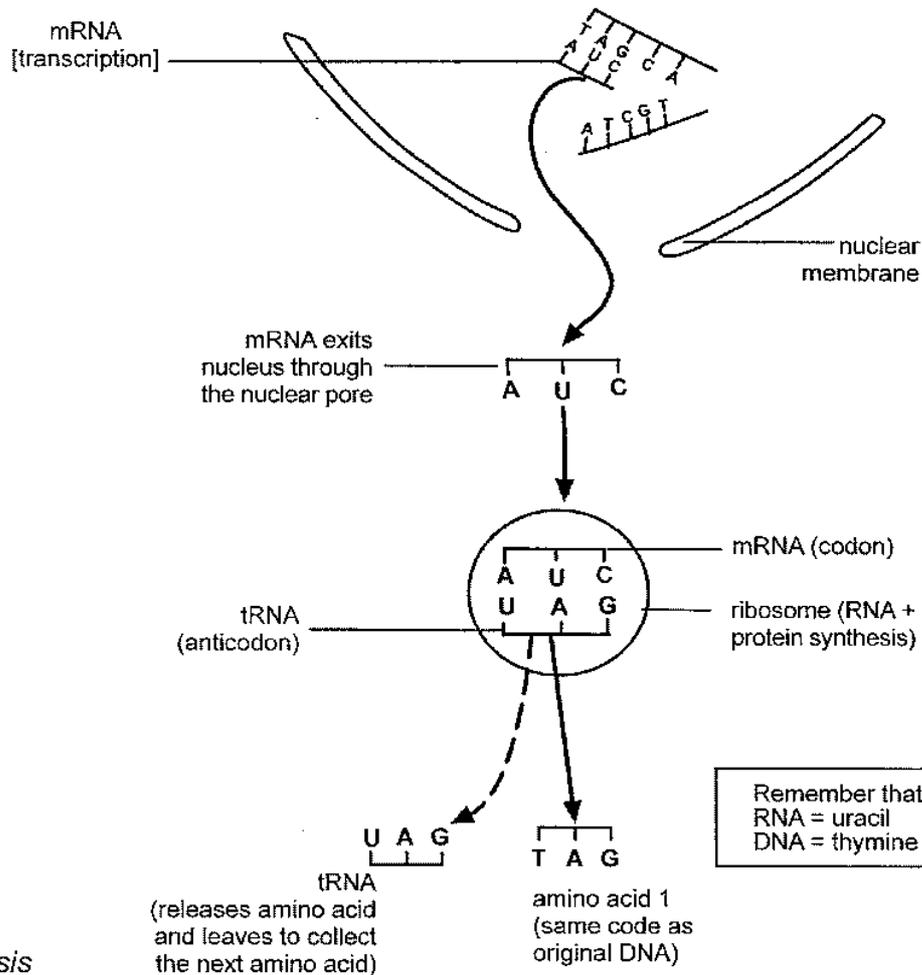
In this session we will focus on summarising what you need to know about:  
The process and importance of protein synthesis and DNA fingerprinting.

### Terminology & Definitions:

- **Messenger RNA (mRNA):** responsible for carrying the genetic code transcribed from DNA to specialized sites of the ribosomes where the information is translated for protein synthesis.
- **Transfer RNA (tRNA):** carries specific amino acids to the mRNA codon in the production of proteins.
- **Ribosomal RNA (rRNA):** form the ribosomes and produce the proteins based on the information from the tRNA.
- **Base pairing:** Purines pair with Pyrimidines - adenine (A) always bonds to thymine (T) and guanine (G) with cytosine (C) in DNA molecule to ensures the precision of DNA replication
- **Codon:** the corresponding three-base sequence (triplet) on the mRNA required to specify one amino acid in a protein chain on the DNA template.
- **Anticodon:** a set of three bases on the tRNA that correspond with the codon on the mRNA.
- **Transcription:** the enzyme controlled process where the base sequence of chromosomal DNA is transferred to mRNA to form a complementary copy.
- **Translation:** the process where the code on a piece of mRNA results in a specific sequence of amino acids, to form a specific protein.

# Protein Synthesis and DNA Fingerprinting

## Key concepts and Diagrams:



Protein synthesis

## What is a protein?

Proteins are macro molecules that contain the elements carbon, hydrogen, oxygen and nitrogen and some may contain sulphur and phosphorus as well. **Amino acids** are the building blocks (monomers) of proteins.

Amino acids are joined by **peptide bonds** to form peptide chains. Peptide chains join to form a protein by a process called **polymerization**. **Protein synthesis** provides the sequence of the amino acids combination that are unique to each individual. Any small change will result in the protein losing the ability to function or it may cause a mutation. All cells, hormones (except sex hormones), antibodies, blood and enzymes consist of proteins.

## X-planation:

### The process of Protein synthesis:

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

**Step 2:** tRNA has an anticodon – picks specific amino acid and carries it to the ribosome where mRNA codon determines the anticodon fit. (For example the mRNA codon of GGG will only accept the tRNA anticodon of CCC and the CCC bases were originally on the DNA triplet)

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**Step 3: Translation:** the tRNA releases the amino acid into the correct place on the polypeptide chain (many peptides).

Each protein is formed specifically to the **genetic code** of the organism that is stored on the DNA in the nucleus of each cell. 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.)

### DNA fingerprinting:

All living organisms have DNA with the same basic chemical structure with the difference being the order of the nitrogenous base sequences. A **DNA profile** is designed by using **DNA probes**. A selection of DNA sequences within the DNA profile forms what is termed the **VNTR** pattern for that individual. Forensic scientists are able to compare the DNA profiles to a sample that is provided from a crime scene. DNA profiling is very accurate.

### Sequencing of DNA:

A species is a group of organisms that are **similar** in appearance, share the **same DNA sequences**, perform the **same mating rituals** and **interbreed**. When the DNA sequence is altered genes mutate by accident. If the mutation is beneficial, it will become a **fixed mutation**, be passed to the next generation resulting in new strains and species. If a mutation is bad, it results in the death of the individual and is termed a **lethal mutation**. When a mutation has no immediate effect on the individual it is termed a **neutral mutation** and is passed on to the next generation. When the environment changes, the organism is adapted to cope with the change. The sequence of the DNA and the number of chromosomes, provides evidence of relationships between groups of organisms. The DNA sequencing of all mammals suggest phylogenetic relationships.

### X-ample Questions:

#### QUESTION 1:

(Taken from NSC Exemplar 2008 Life Science Paper 1 Question 3)

The following questions are based on protein synthesis.

1.1. Describe each of the following:

- a) Transcription (see the definitions) (2)
- b) Translation (see the definitions) (2)

1.2. The diagram below shows the sequence of nitrogenous bases of a strand of DNA that codes for part of a protein molecule.

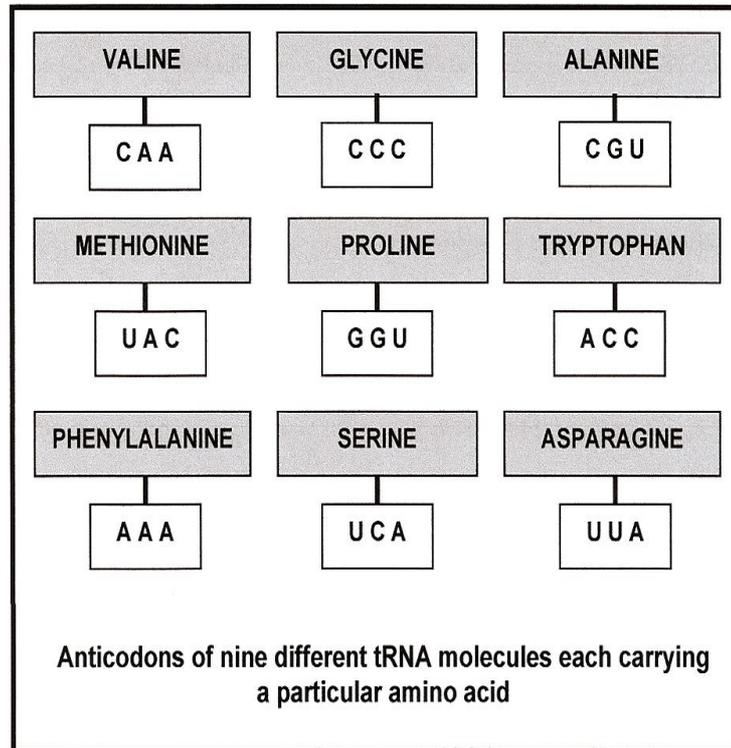
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GTT - ATG - TGG

Write down the mRNA codon sequence that reads from left to right from the DNA sequence above. (3)

(Remember that this is the codon sequence and RNA contains Uracil)

1.3. The following diagram shows the anticodons of nine different tRNA molecules each carrying a particular amino acid.



Select and write down from the above diagram the amino acids (in the correct sequence) that would be required for the base sequence of mRNA shown below: (The anticodon will be the complementary base for the codon).

UUU - GUU - AUG

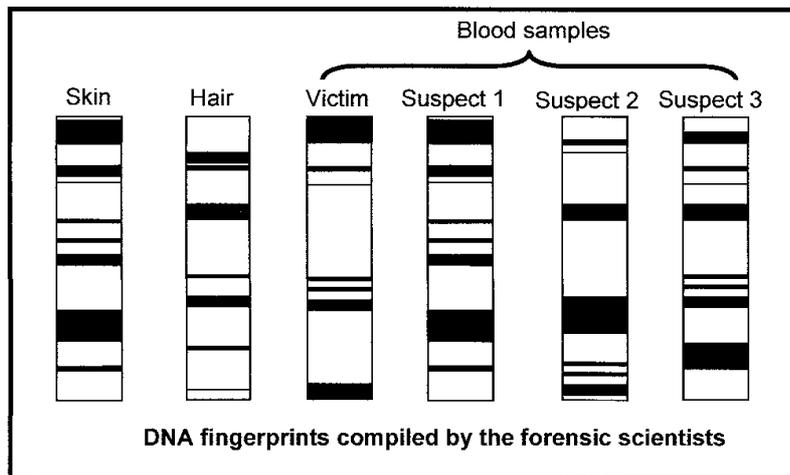
(3)

### QUESTION 2:

(Taken from NSC Exemplar 2008 Life Science Paper 1 Question 3)

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

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- 2.1. Did the DNA from the hair and skin tissue come from the same person? (1)
- 2.2. What conclusion can you make from QUESTION 2.1. about the possible number of people involved in the murder? (2)
- 2.3. Which of the three suspects might have been involved in the murder? (1)
- 2.4. Give a reason for your answer to QUESTION 2.3. (1)
- 2.5. Do you think that the DNA evidence on its own is enough to convict a suspect? (1)
- 2.6. Give a reason for your answer to QUESTION 2.5. (2)
- 2.7. 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)

### X-ercise:

1. 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.
  
2. The monomers of proteins are:
  - A nucleotides
  - B triplets
  - C anticodons
  - D amino acids
  
3. In DNA fingerprinting, Scientists use a small number of sequences of DNA called:
  - A mtDNA
  - B tRNA
  - C VNTR pattern
  - D triplet bases

## Protein Synthesis and DNA Fingerprinting

4. 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

### Answers to the X-exercise questions:

1. A
2. D
3. C
4. A