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# EB Education Revision Guide


## How to work with Protein Synthesis

...helping everybody achieve Even Better

# How proteins are made

## What are proteins?

DNA controls the production of proteins.

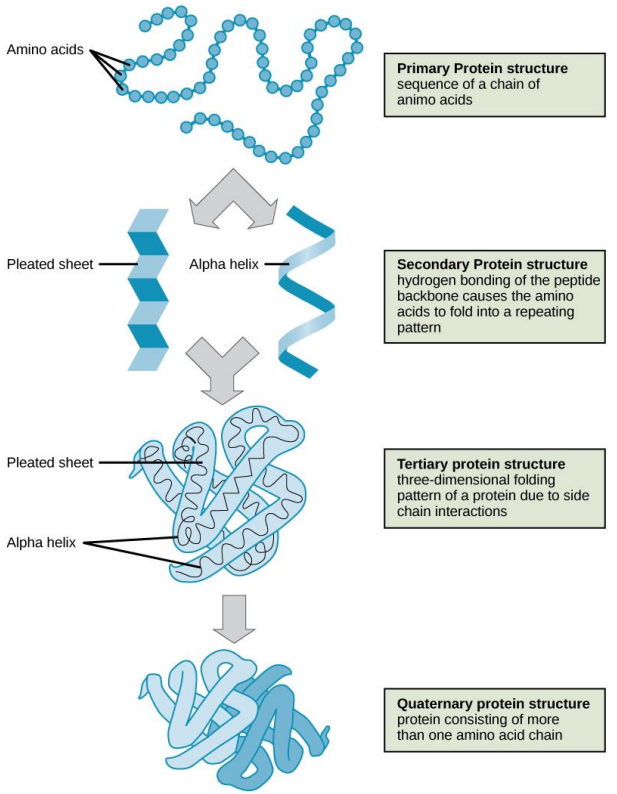
There are different types of proteins:

- Structural proteins, like collagen and keratin
- Hormones
- Enzymes
- Antibodies
- Carrier molecules like haemoglobin

Proteins are made of chains of amino acids. Every protein has a different number and order of amino acids.

The chain of amino acids then folds up and gives each protein a specific shape, which means all proteins have a different function (for example enzymes having a specific shaped active site to catalyse a specific reaction).

## Diagram



# How proteins are made

Genes are sections of DNA.

Each gene is a code for creating a specific protein. The order of bases in the gene controls the order of amino acids in the protein molecule. The proteins are then folded into their correct shape to make them functional.

Each amino acid is coded for by a sequence of three bases in the gene called a **base triplet**.

The amino acids are then joined together in a long chain to make a protein molecule, following the order of the bases in the gene.

Each protein is made of large numbers of amino acids.

Many regions of DNA are **non–coding**, meaning they do not code for any amino acids.

All of the DNA in an organism (coding and non-coding), makes up the organism's **genome**.

## Diagram

# How proteins are made

## Transcription

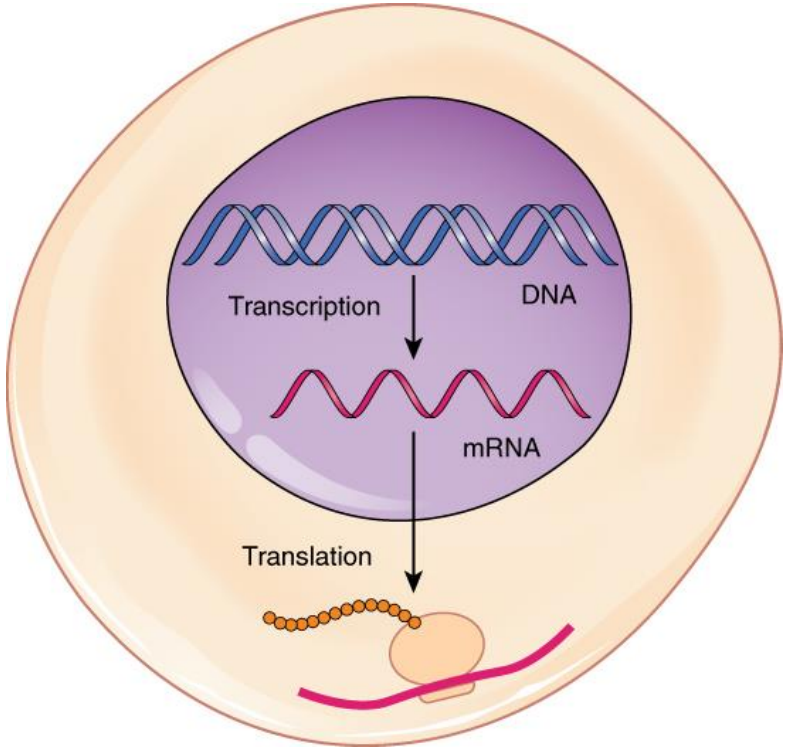
Proteins are made in two stages.

The first stage is known as **transcription**.

DNA is in the nucleus and cannot move out as it is too large, but proteins are made in structures called ribosomes, which are found in the cytoplasm.

Information from the DNA needs to get to the ribosomes. This is done by copying or **transcribing** the base sequence of DNA into another molecule called messenger RNA (mRNA).

mRNA is polymer of nucleotides, like DNA, but it is smaller, just a single strand, so it can move out of the nucleus. It also uses uracil (U) instead of thymine (T).

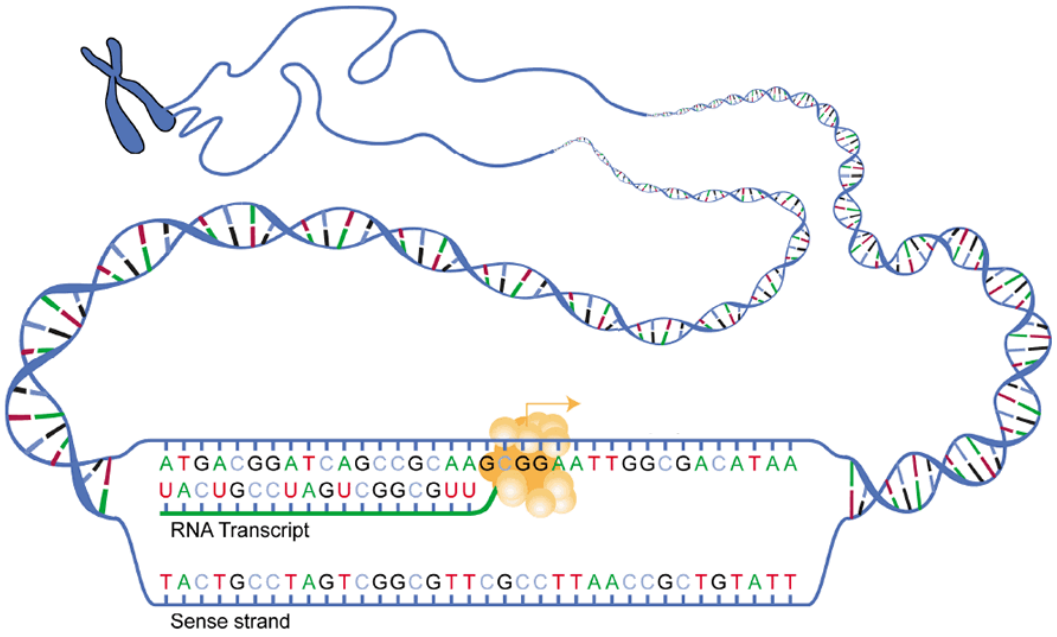


# How proteins are made: Stage 1

## Transcription

- The two strands of the DNA helix are unzipped by breaking the weak hydrogen bonds between base pairs.
- The enzyme RNA polymerase attaches to the DNA in a non-coding region just before the gene.
- RNA polymerase moves along the DNA strand. It uses the coding DNA in the gene (the order of bases) as a template to make the mRNA. Free RNA nucleotides form hydrogen bonds with the exposed DNA strand nucleotides by complementary base pairing to form a strand of mRNA.
- Because the opposite base bonds with the exposed DNA bases, the strand of mRNA is an opposite copy of the DNA strand (except that U replaces T). We call this a complementary copy.
- The newly formed strand of mRNA leaves the nucleus and travels to the ribosome

## Diagram

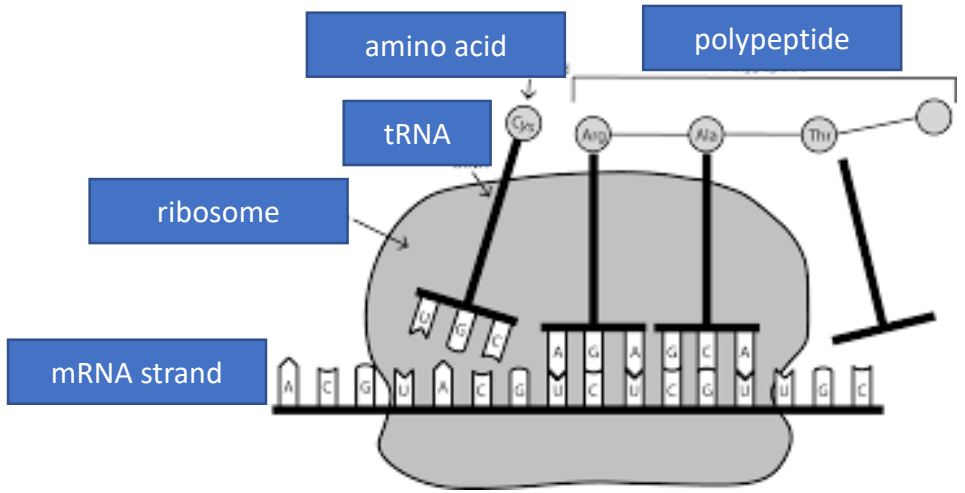


# How proteins are made: Stage 2

## Translation

The mRNA strand travels through the cytoplasm and attaches to the ribosome.

- Amino acids are brought to the ribosome by another RNA molecule called transfer RNA (tRNA).
- Base triplets in the mRNA are known as **codons**. Each tRNA molecule has three bases, known as the **anticodon**. For every codon on the mRNA, a complementary molecule of tRNA is lined up. Each tRNA will transport a specific amino acid depending on their anticodon. The pairing of the codon and anticodons makes sure the amino acids are brought to the ribosome in the right order. Once the tRNA has brought the amino acid to the ribosome it leaves to collect another amino acid.
- The amino acids are joined together in the correct order by the ribosome to make a protein (polypeptide).



# Mutations

## What is a mutation?

A mutation is a random change to an organism's DNA base sequence that can be inherited if it occurs in gametes.

Mutations can be caused by radiation and some chemicals that we come into contact with.

Sometimes these mutations can be harmful, causing the cell to die or divide uncontrollably (potentially becoming cancerous). Sometimes the mutations have no effect. Occasionally the changes can be beneficial, producing new and useful characteristics.

When a mutation happens it will produce a **genetic variant** (a different allele or version of the gene).

The genetic variant may code for a different sequence of amino acids. This may result in the protein produced having a different shape and therefore altering its activity, or its characteristics (phenotypes).

# Mutations

## Non-Coding DNA

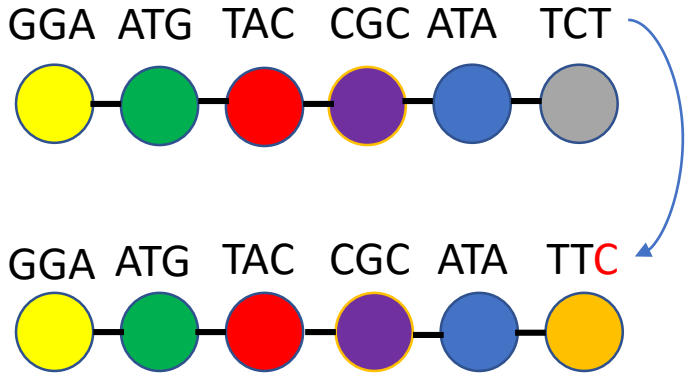
Mutations can occur in coding and non-coding regions of DNA.

RNA polymerase needs to bind to a region of non-coding DNA in front of a gene before transcription takes place.

If a mutation occurs in this non-coding region, it can make it easier or more difficult for the RNA polymerase to bind to it .

How well the RNA polymerase can bind to the DNA will affect how much mRNA is transcribed, and therefore how much of the protein is made.

The phenotype of the organism could be affected by how much of the protein is made, depending on what its function is.



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# Your turn:

1. mRNA is made by transcribing information in a DNA strand.

a) Describe how the mRNA strand is used to make proteins and where this happens.

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b) The diagram below shows a short section of DNA from a kiwi fruit.

A G C C A G C G A A G C

T C G G T C G C T T C G

How many codons can be seen in this section of DNA?

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c) Part of one DNA strand is show below.
Complete the boxes to show the mRNA strand which will be coded for by the DNA strand.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C | C | G | A | T | C | A | A | C |
| | | | | | | | | |

d) What is the maximum number of amino acids coded for by this DNA strand?

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# Your turn:

2. The structure of a protein is determined by the DNA.
Describe how.

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3. Amino acids are joined together to make proteins.
In the table below some of the amino acids which are coded for by DNA bases are shown.

| DNA bases | TTC | TAC | AAA | AAC | CAA |
|---|---|---|---|---|---|
| Amino acid | lys | met | phe | leu | val |

a) Look at the section of DNA below and state the order of amino acids coded for.

C A A T T C T A C

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b) During which stage of protein synthesis will these amino acids be joined together?

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# Your turn:

4. Mutations are changes in DNA. Describe how a mutation could affect the action of an enzyme.

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5. Antigens on the surface of pathogens can be proteins, which have a specific sequence of amino acids.
Explain how the sequence of the gene determines the order of amino acids in a protein.

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# Answers:

1. mRNA is made by transcribing information in a DNA strand.

a) Describe how the mRNA strand is used to make proteins and where this happens.

This is known as translation.
The mRNA leaves the nucleus and attaches to a ribosome in the cytoplasm.
tRNA molecules carry amino acids.
tRNA joins to the mRNA when the bases on the tRNA (triplet of bases – or anticodon) match the bases (triplet code or codon) on the mRNA.
The amino acids are joined together in the correct order to make polypeptides (or proteins).

b) The diagram below shows a short section of DNA from a kiwi fruit.

A G C C A G C G A A G C
T C G G T C G C T T C G

How many codons can be seen in this section of DNA?

4

c) Part of one DNA strand is show below.
Complete the boxes to show the mRNA strand which will be coded for by the DNA strand.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C | C | G | A | T | C | A | A | C |
| G | G | C | U | A | G | U | U | G |

d) What is the maximum number of amino acids coded for by this DNA strand?

3

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# Answers:

2. The structure of a protein is determined by the DNA.
Describe how.

A gene codes for the production of 1 protein.
The sequence of bases in the gene will determine the sequence of amino acids.
Each codon/triplet/3 bases codes for 1 amino acid.
Many amino acids joined together make up a protein.
Protein synthesis involves transcription (when mRNA is produced) and translation (tRNA brings amino acids to match the codons on the mRNA).

3. Amino acids are joined together to make proteins.
In the table below some of the amino acids which are coded for by DNA bases are shown.

| DNA bases | TTC | TAC | AAA | AAC | CAA |
|---|---|---|---|---|---|
| Amino acid | lys | met | phe | leu | val |

a) Look at the section of DNA below and state the order of amino acids coded for.

C A A T T C T A C

val lys met

b) During which stage of protein synthesis will these amino acids be joined together?

translation

# Answers:

4. Mutations are changes in DNA. Describe how a mutation could affect the action of an enzyme.

A mutation is a change in the sequence of bases in a gene and this can then cause a change in the order of amino acids.
If the order of amino acids changes, then it can lead to a change in shape of the protein (or active site of enzyme)
The enzyme may no longer be able to function/may have reduced function/could be more effective

5. Antigens on the surface of pathogens can be proteins, which have a specific sequence of amino acids.
Explain how the sequence of the gene determines the order of amino acids in a protein.

A single strand of messenger RNA is transcribed from the gene in the nucleus.
The mRNA then binds to the ribosome.
The triplet code from the mRNA is matched by a complementary tRNA anticodon at the ribosome.
tRNA transfers amino acids to the polypeptide chain in a specific order.

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# For more help and resources, or to work with us as a tutor, please contact us


www.ebeducationservices.co.uk

contact@ebeducationservices.co.uk

0161 442 5270


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