Protein Synthesis Notes

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As we have learned an organism's DNA has all of the genes that code of things such as eye colour, skin colour and blood type. But how does this information get translated into results that we can see? The word for a gene being used is "expressed". When a gene is expressed a protein is made or synthesised.

Protein synthesis: is a two-stage process that sees the production of proteins by the ribosomes of the cell.

When a cell does protein synthesis it has one major problem. The DNA with all the instructions to make the protein is in the nucleus, but the ribosomes (the sites where the protein can be made) are found in the cytoplasm. The DNA cannot get to the ribosome, it's too big to get out of the nucleus!

The cell needs a work around. Instead of sending all of the DNA into the cytoplasm, which it can't do, the cell copies or **transcribes (rewrites)** the gene that it wants. It then sends this copy out through the nucleus to the cytoplasm. This is the first stage of protein synthesis – **Transcription.**

Where does each stage of protein synthesis happen? Transcription takes place in the nucleus and translation takes place in the cytoplasm of the cell.

Before we look at the details of transcription let's look at the two molecules we will mention a lot in the description, **mRNA and tRNA.**

RNA: stands for ribonucleic acid.

RNA is very similar to DNA but has a few really important differences.

1. It is single stranded. While DNA is double stranded.
2. It has the base Uracil instead of Thymine.

mRNA = messenger RNA	tRNA = transfer RNA
• **Made in the Nucleus.** • **Copies DNA and leaves through pores in the nucleus. Then it attaches to a ribosome.**	• **It carries the amino acids that are used to make proteins to the ribosomes during translation.**

Protein synthesis stage 1: Transcription

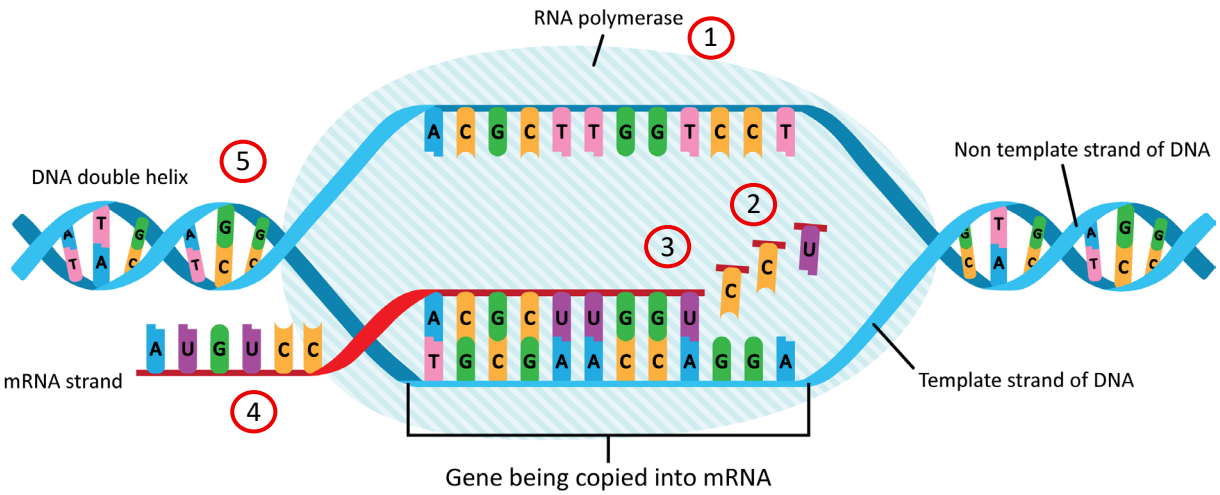
Step 1: The DNA double helix unzips as hydrogen bonds between complementary bases break and the two polynucleotide strands separate. This is done by the enzyme RNA polymerase.

Step 2: One strand, called the **template strand** acts as a template. Free RNA nucleotides complementary base pair to the exposed bases on this strand by forming hydrogen bonds.

Step 3: RNA polymerase forms sugar-phosphate bonds between its nucleotides. This is the red line of the mRNA strand.

Step 4: The mRNA detaches from the template strand and leaves the nucleus.

Step 5: The two DNA strands re-join together by complementary base pairing. The DNA molecule winds back up into a helix.



Coding and Non-coding DNA

Codons or triplets: are groups of **three nucleotide bases** that code for an amino acid. For example, AUG is a codon/ triplet made up of adenine, uracil and guanine.

AUGCCCGGGUCG – this section of mRNA shows **four** codons or triplets

If were to look back the original DNA strands in the nucleus, we would find that not all of the DNA is actually used to make proteins. The genome is divided into **coding DNA** and **non-coding DNA**.

Coding DNA: sections of DNA (genes) that code for the production of specific proteins.

Non-coding DNA: sections of DNA that do not code for a protein.

So, what does non-coding DNA actually do? It isn't just "junk" DNA! Non-coding DNA plays a vital role in controlling our genes. Non-coding parts of DNA can switch genes on and off. This means they control when and where a specific protein is produced in the body.

What happens if there is a mutation in non-coding DNA? If a mutation (a change in the base sequence) happens in a non-coding region, it won't change the actual shape of the protein being made. **BUT**, it can affect how the gene is expressed.

- A mutation here might stop a gene from being switched on (so a vital protein is never made).
- Or, it might switch a gene on when it shouldn't be (which can lead to uncontrolled cell division, like cancer).

Exam note: If an AQA exam question asks about the function of non-coding DNA, the ideal answer they are looking for is that it "switches genes on and off" or controls "gene expression" 😊

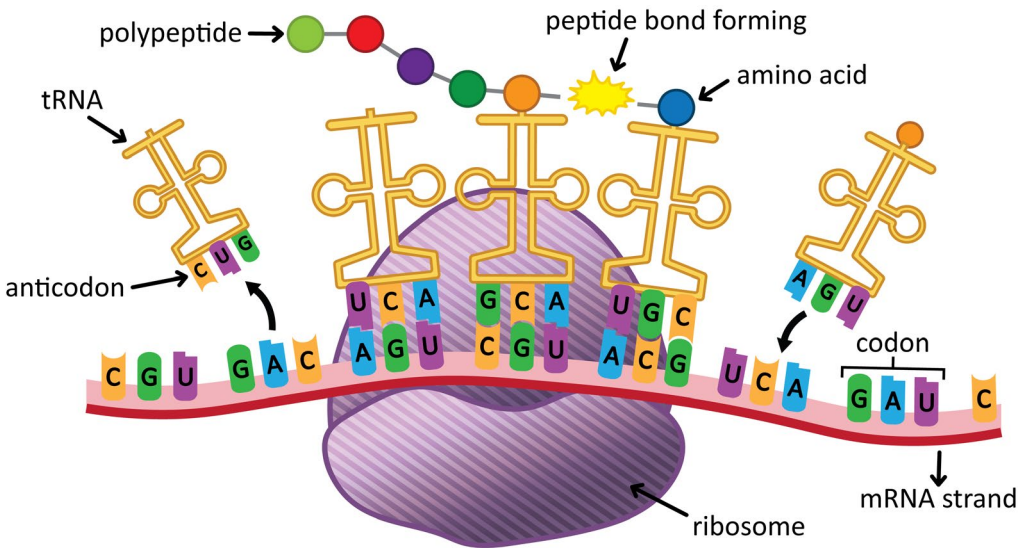
Protein Synthesis Stage 2: Translation

Step 1: The mRNA strand moves through the cytoplasm and attaches to a ribosome.
Step 2: The ribosome "reads" the mRNA strand in groups of three called a codon.

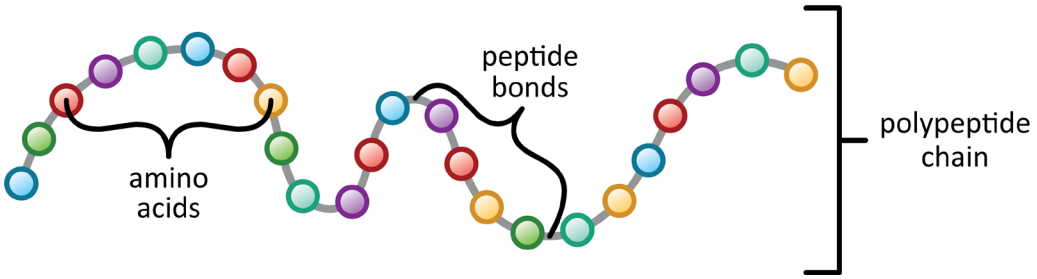
Step 3: tRNA molecules transport specific amino acids to the ribosome which they leave opposite the anticodon. A peptide bond forms between amino acids which have been brought to the ribosome by the tRNA.

Step 4: "Empty" tRNA molecules, that have left their amino acids behind, exit the ribosome and collect another specific amino acid in the cytoplasm.

Step 5: The ribosome continues to move along the mRNA strand reading codons and matching it to their anti-codon. This continues until the ribosome hits the stop codon. Just like a full stop at the end of a sentence it tells the ribosome to stop synthesising the polypeptide.



The figure below shows the polypeptide chain that is made at the end of protein synthesis.



Mutations

As we saw, in protein synthesis, sections of DNA are copied and then turned into strands of mRNA and then these are turned into sequences of amino acids. When we copy things we can make mistakes and the same is true about protein synthesis, errors can happen. When one of these errors happens we say there has been a **mutation**.

A mutation: a rare, random change to the sequence of bases in DNA.

What causes mutations? Mutations happen continuously and naturally as DNA copies itself. However, the chance of a mutation happening is increased by exposure to:

1. Ionising radiation for example UV light, X-rays and gamma rays.
2. Chemical mutagens for example chemicals found in tobacco smoke and tar.

To understand how mutations affect an organism, we have to look at <u>where in the DNA the mutation happens</u>. It could take place in the **coding DNA** and **non-coding DNA**.

A mutation: a rare, random change to the sequence of bases in DNA.

An exam question could ask:

"How can a mutation or change of an amino acid affect the protein made?"

This is quite a popular exam question.

This is the ideal answer 😊

1. If there is a change in a base/base sequence/order of bases / a change in mRNA
2. This will cause a change in an amino acid / order of amino acids.
3. This could change the shape of the protein. If the protein is an enzyme this could change the shape of the active site which could cause the enzyme to not function.