

Protein synthesis

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Proteins are polymers made of amino acids, and they do all sorts of incredible things. The instructions on how to make proteins, contained in our DNA, are passed on by a molecule called messenger RNA (mRNA). mRNA interacts with a protein-RNA complex called a ribosome and transfer RNA (tRNA) to produce proteins, in a process called translation.

RNA polymerase

1

DNA

Nucleus

Nuclear pore

Cytoplasm

Polypeptide chain

9

8

Aminoacyl-tRNA synthetase enzyme

Cytoplasm

Endoplasmic reticulum

Ribosome

11

Cytoplasm

Vesicle

12

Glycoprotein

Golgi apparatus

Transcription

- 1 Single-stranded mRNA is made using a strand of DNA as a template.
- 2 The mRNA leaves the nucleus through a nuclear pore and attaches to a ribosome.

Translation

- 3 A tRNA molecule brings the correct amino acid to the ribosome, attaching to the mRNA with a complementary anticodon to the codon currently being read.
- 4 The ribosome processes the mRNA, one codon at a time.
- 5 Catalysed by the ribosome, neighbouring amino acids link together with a peptide bond.
- 6 Steps 3, 4 and 5 repeat continuously, forming a polypeptide chain (primary structure) that leaves the ribosome.
- 7 The tRNA is released into the cytoplasm after losing its amino acid to the growing peptide chain.
- 8 An aminoacyl-tRNA synthetase enzyme specific to a particular amino acid adds that amino acid to the correct tRNA.
- 9 The tRNA carries the amino acid to the ribosome for translation.
- 10 mRNAs have different 'lifespans' but are all broken down after use.

Post-translational modification

- 11 As the protein chain leaves the ribosome, it folds to form its secondary and tertiary structure. Additional polypeptide chains may be added to form a quaternary structure.
- 12 Proteins destined for the cell membrane or export are inserted into the endoplasmic reticulum by ribosomes on its surface. They are then transported to the Golgi apparatus for post-translational processing and packaging. Sugar groups may be added for labelling. Other proteins remain in the cell.

Glossary

Aminoacyl tRNA synthetase: An enzyme that catalyses the binding of an amino acid to a tRNA molecule. There are at least 20 different types of this enzyme in the cell, each specific to a different amino acid.

Anticodon: A group of three bases at one end of a tRNA molecule that is complementary to an mRNA codon.

Codon: A group of three bases in mRNA that codes for a specific amino acid.

Complementary: Matching. Complementary bases are those that pair up in DNA and RNA, such as cytosine (C) with guanine (G).

Golgi apparatus: An organelle that modifies proteins for export from the cell.

mRNA (messenger RNA): Used to transfer the gene sequence for a protein from the DNA in the nucleus to the ribosome, where it is 'read' to make protein.

Primary structure: The amino acids that make up the protein or polypeptide chain, linked by peptide bonds.

Quaternary structure: The way that different polypeptide chains are arranged if a protein has more than one subunit.

Ribosome: A molecular machine made of ribosomal RNA and protein with a large and small subunit. This is where translation occurs.

RNA: A single strand of nucleic acid. It is similar to DNA but uses the base uracil (U) instead of thymine (T).

Secondary structure: The shape that the chain of amino acids takes. Includes 'elements' such as helices and beta-pleated sheets, depending on the type of protein.

Tertiary structure: The unique three-dimensional shape that the protein takes. The shape is held together by interactions between the side chains of amino acids, including hydrogen bonds, disulphide bonds, ionic and hydrophobic interactions, and van der Waals forces.

Transcription: The process of copying a strand of DNA into mRNA.

Translation: The process of using the genetic information in mRNA to make a protein chain from amino acids. This is performed by ribosomes.

tRNA (transfer RNA): Key adaptor molecules needed for translation. Each tRNA recognises a particular codon and ensures the correct amino acid is brought to the ribosome's active site for protein synthesis.