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Editorial Note

Development Editor Note: Protein Biosynthesis

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Protein biosynthesis (or protein synthesis) is a crucial biological mechanism that occurs within cells, balancing the loss of cellular proteins by generating new proteins (via degradation or export). As enzymes, structural proteins, or hormones, proteins perform a variety of essential functions. For both prokaryotes and eukaryotes, protein synthesis is a very similar process but with distinct differences.

It is possible to broadly divide protein synthesis into two phases - transcription and translation. A portion of DNA encoding a protein, known as a gene, is translated into a template molecule called messenger RNA during transcription (mRNA). This conversion is performed by enzymes in the nucleus of the cell, known as RNA polymerases.

The mature mRNA is exported from the cell nucleus via nuclear pores to the cytoplasm of the cell for translation to occur. During translation, the mRNA is read by ribosomes which use the nucleotide sequence of the mRNA to determine the sequence of amino acids. The ribosomes catalyze the formation of covalent peptide bonds between the encoded amino acids to form a polypeptide chain.

The polypeptide chain must fold after translation to form a functional protein; the polypeptide chain must fold properly to function as an enzyme, for example, to create a functional active site. In order to follow a functional three-dimensional (3D) shape, a set of smaller underlying structures called secondary structures must first form the polypeptide chain. In these secondary structures, the polypeptide chain then folds to create the overall 3D tertiary structure. When correctly folded, via various post-translational modifications, the protein may undergo further maturation. Post-translational changes will affect the ability of the protein to function where it is located inside the cell (e.g. cytoplasm or nucleus).

Protein biosynthesis plays a key role in disease, as changes and failures in this process are often the underlying causes of a disease by underlying DNA mutations or protein misfolding. The subsequent mRNA sequence, which then changes the mRNA encoded amino acid sequence, is modified by DNA mutations. By generating a stop sequence which causes early termination of translation, mutations may cause the polypeptide chain to be shorter. Alternatively, the particular amino acid encoded at that position in the polypeptide chain alters a mutation in the mRNA sequence.

The protein's ability to act or to fold properly may be impaired by this amino acid change. Misfolded proteins are frequently involved in disease since poorly folded proteins appear to bind together to form dense clumps of protein. These clumps are linked to a variety of disorders, including Alzheimer's disease and Parkinson's disease, mostly neurological. Protein biosynthesis in the nucleus starts with transcription and post-transcriptional changes. Then it exports the mature mRNA to the cytoplasm where it is translated. Then, the polypeptide chain folds and is modified post-translationally.

Owing to the direct relation between the DNA nucleotide sequence and the amino acid sequence of the encoded protein, many diseases are caused by mutations in genes. Protein misfolding or malfunctioning may result from changes to the primary structure of the protein. As a cause of several diseases, including sickle cell disease, mutations within a single gene have been recognized.