Protein synthesis in dna processes

Protein synthesis is the process whereby DNA encodes for the production of amino acids and proteins. It is a very complex and precise process and as proteins make up over half of the dry mass of a cell, it is a vital process to the maintenance, growth and development of the cell. Proteins are widely used in the cell for a variety of reasons and have many different roles, for example some proteins provide structural support for cells while others act as enzymes which control cell metabolism.

The formation of proteins takes place within the cytoplasm, the portion of the cell located just outside the nucleus. Proteins are formed through condensation reactions which bond amino acids together with peptide bonds in a particular sequence and the type of protein that is created is defined by the unique sequence of the amino acids. DNA and RNA are nucleic acids that are formed in the nucleotides and are both involved in the process of protein synthesis.

Deoxyribonucleic acid, more commonly known as DNA, is located within the nucleus of the cell and contains the entire genetic code for an organism within its structure. DNA has two very important functions which are: to convey information from one generation of cells to the next by the process of DNA replication and to provide the information for the synthesis of proteins necessary for cellular function. Basically, DNA controls protein synthesis.

The complex and precise process of protein synthesis begins within a gene, which is a distinct portion of a cell's DNA. DNA is a nucleic acid which is made up of repeating monomers, called nucleotides, and in the case of DNA, these individual monomers consist of a pentose sugar, a phosphoric acid and four bases known as adenine, guanine, cytosine and thymine. DNA is a double stranded polymer, which has a twisted ladder like structure, known as a double-helix. The double-helix of DNA is formed when two polynucleotide chains join together via base-pairing between nucleotide units within the individual chains. The base pairs are joined together themselves by hydrogen bonds and the pairings join in a very specific way, for example guanine will always only join with cytosine and adenine with always only join with thymine. The sequence of these base pairs along the DNA molecule carries all the genetic information of the cell.

Although the DNA does not produce the new proteins itself, it is responsible for controlling the process of protein synthesis. This is simply because DNA is far too big a structure to pass through the nucleus into the cytoplasm, so instead it sends a message to the ‘ protein making machine’ in the cytoplasm to start the process. It does this by sending this information via a chemical similar to DNA called ribonucleic acid (RNA). RNA is single stranded polymer of nucleotides which is formed on the DNA. There are three types of RNA found in cells, all of which are involved in process of protein synthesis. They are Messenger RNA (mRNA), Ribosomal RNA (rRNA) and Transfer RNA (tRNA).

Messenger RNA (mRNA) is a long, single stranded molecule which is formed into a helix on a single strand of DNA. It is manufactured in the nucleus and is a mirror copy of the part of the DNA strand on which it is formed. The messenger RNA passes through the nucleus and enters the cytoplasm where is connects with the ribosomes and acts as a template for protein synthesis.

Ribosomal RNA (rRNA) is a large, complex molecule which is made up of both single and double helices. rRNA is formed by the genes which are situated on the DNA and is found in the cytoplasm which, when bonded with proteins, makes up the ribosomes. The difference between DNA and RNA is that DNA is a double helix consisting of two strands whereas RNA is simply a singular strand, RNA also uses uracil instead of thymine and DNA consists of a deoxyribose sugar, whereas RNA consists of a ribose sugar.

Transfer RNA (tRNA) is a very small, single stranded molecule that is manufactured by the DNA in the nucleus and is primarily responsible for the transfer of amino acids. These amino acids are found in the cytoplasm, at the ribosomes and operates as an intermediary molecule between the triplet code of mRNA and the amino acid sequence of the polypeptide chain. " It forms a clover-leaf shape, with one end of the chain ending in a cytosine-cytosine-adenine sequence" (Toole, 1997). There are at least twenty different types of tRNA, each transporting a different amino acid and at a central point along the chain there is a significant sequence of three bases, called the anticodon. These are arranged along the appropriate codon on the mRNA during protein synthesis.

All proteins are encoded for in DNA, and the unit of DNA which codes for a protein is its gene. Since amino acids are regularly found within the proteins, it can then be assumed that the amino acids must have their own code of bases on the DNA. This relationship between the bases and the amino acids is called the genetic code. There are just twenty amino acids that regularly occur in proteins and each must be coded for in the bases of the DNA. With the DNA only having four different bases present, if each were to code for a different amino acid, then only four different amino acids could be coded for. With there being twenty amino acids that occur regularly in proteins, only a code composed of three bases could satisfy the requirements for all twenty amino acids; this is called the triplet code and this triplet code is more commonly known as a codon. Out of the 64 codons can be formed, three of these designate the termination of a message and these are called stop codons (UAA, UGA, UAG) and one codon (AUG) acts as the start signal for protein synthesis. The codon is a universal code, i. e. it is the same triplet code for the same amino acids in all living organisms. As there is more than one triplet code for most amino acids, it is called a degenerate code and each triplet must be read separately and must not over-lap. For example, CUGAGCUAG is read as CUG-AGC-UAG. (Toole, 1997)

Protein synthesis is the process that is concerned with transfer of the information from the triplet code on the DNA to ensure the formation of the proteins. There are four stages in the formation of the proteins, these are: synthesis of amino acids; transcription; amino acid activation and translation.

The first stage, the synthesis of amino acids, is concerned with the formation of amino acids. The human body is able to synthesise amino acids, however it is not able to form the required amount therefore the remaining amino acids are supplied from the food that is ingested.

The second stage, transcription, is the process where a specific region of the DNA molecule that codes for a polypeptide is copied to form a strand of mRNA. Since the DNA is far too big a structure to pass through the membrane of the nucleus itself, the process of transcription takes place within the nucleus. Firstly, a section of the DNA separates as a result of hydrogen bonds between the bases being broken, causing the DNA to unwind into single strands. One strand functions as a template and the enzyme called RNA polymerase moves along the strand attaching RNA nucleotides one at a time to the newly exposed strand on DNA. This mRNA sequence is known as the sense strand and the complementary DNA sequence which serves as the transcriptional template is known as the antisense strand. Using complimentary base pairing of nucleotides, the mRNA is an exact replica of the unused strand called the copy strand. The process of transcription continues until the polymerase reaches the stop codon and the fully formed mRNA moves out of the nuclear membrane, through the nuclear pores, to the ribosomes.

The third stage, amino acid activation, is the process by which the amino acid combines with tRNA using energy from ATP. There are twenty different types of tRNA which bond with a specific amino acid and the amino acid is attached to the free end of the tRNA. The newly formed tRNA-amino acid begins to move toward the ribosomes in the cytoplasm.

The fourth and final stage of protein synthesis occurs in the cytoplasm at the ribosomes, and is called translation. Translation is the means by which a specific sequence of amino acids is formed in accordance with the codons on the mRNA. Each mRNA molecule becomes attached to one or more ribosomes to form a structure called a polysome. When translation occurs, the complimentary anticodon of a tRNA-amino acid complex is attracted to the first codon on the mRNA and binds to the mRNA with hydrogen bonds between the complimentary base pairings. A second tRNA binds to the second codon of mRNA in the same way. The ribosome acts as a framework which holds the mRNA and tRNA amino acid complex together until the two amino acids are joined together by the formation of a peptide bond. As the ribosome moves along the mRNA each codon is recognised by a matching complementary tRNA which contributes its amino acid to the end of a new growing protein chain. This process continues until the ribosome reaches a stop codon, which then indicates that the polypeptide chain is finished and the polypeptide chain is then cast off. The formed polypeptides are then assembled into proteins and by this action, protein synthesis is complete.

In conclusion, the DNA molecules contain a genetic code that determines which proteins are made in the body and these proteins include certain enzymes which control every biological reaction going on within the body. In simple terms, this is basically how life works.