# Technical note 1

## *DNA function*

Deoxyribonucleic acid (DNA) is a long, double stranded, helical molecule that contains building blocks (nucleotide bases) in a sequence which encodes instructions for all the metabolic processes in the human body, These range from growth and development through specific biochemical interactions involved in the digestion of food and synthesis of new molecules. DNA regulates its own expression and controls the production of proteins: structural proteins, **used to build the framework of cells, organs, and tissues; and enzymes, used to perform biochemical activity. There are two major processes involved in putting this information to use in the body-transcription and translation.**

Transcription is the simplest of these two processes. It consists of making an RNA (ribonucleic acid) copy of the DNA. This copy is then used to transport the instructions from the DNA to the protein building apparatus in the cell, outside the nucleus. This RNA copy of the DNA is called '(messenger RNA" (mRNA) because the message it carries from the gene allows the construction of the specified protein.

The process by which the mRNA is formed is very simple, taking advantage of the unique properties of nucleic acids (DNA and RNA). The double stranded DNA molecule separates, or unzips, at which point specific proteins present in the nucleus (enzymes) recognise precise signals present in the DNA (e.g., sequences of nucleotide **bases, such as TTAA) and attach to the DNA at those sites. One enzyme (called an RNA polymerase) then moves along the DNA molecule, constructing an mRNA molecule that has a complementary sequence of nucleotide bases (i.e., where there is an A in the DNA, the mRNA polymerase will add a T to the growing polymer). The end result is an RNA molecule that is a mirror image of the DNA region, or gene, which can then direct the assembly of a specific product.**

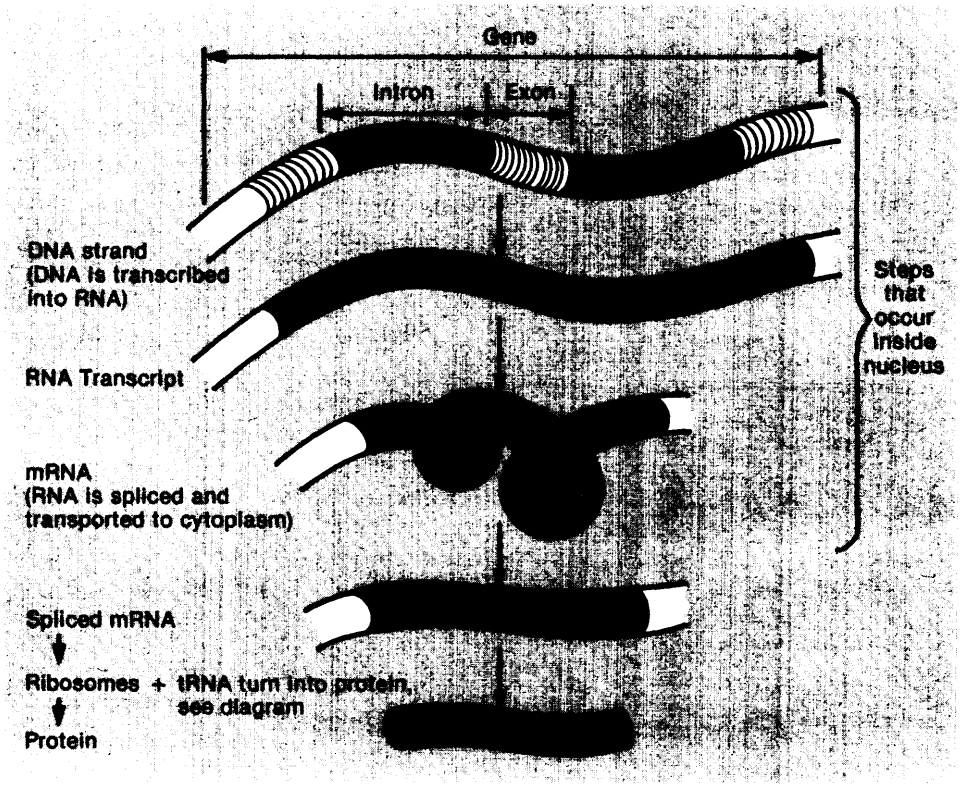
**Before this mRNA molecule is used to assemble a protein in the process of translation, however, it must first be subtly modified; trimmed and tucked, as it were, so as to more precisely fit its function. There are several of these trimming processes and they are known altogether as "mRNA processing" or "post-transcriptional modification". Our understanding of these processes is incomplete, but the two best known are "excision/ligation" and "methylation. "**

**Excision/ligation is most similar to an editing process, and it is necessary because many genes contain more nucleotide bases than are necessary to code for the number of amino acids the finished protein will contain. Within a given gene there are two types of regions:** "exons," **or expressed regions, and** '(in= trons, " or intervening regions. Exons contain the information that precisely directs the assembly of the protein product, that is, the sequence of amino acids added to the growing protein chain during translation. Introns, on the other hand, are the regions found between expressed regions. Their function is unclear; one hypothesis is that introns are involved in regulating gene expression (which includes turning genes on and off and controlling the number of mRNA molecules produced, and therefore the amount of gene product). The original mRNA transcript is thus trimmed and spliced by specific enzymes and transported from the nucleus to the cytoplasm, where it is decoded or translated into protein (see diagram).

Methylation refers to the process of attaching a small molecule (a methyl group, or a carbon with three attached hydrogens, CH3) to the backside of one of the nucleotide bases in the mRNA. The reason for this is not completely understood, but it is thought that methylation alters the mRNA in **such a way that some enzymes responsible for degrading it will not do so as quickly as they otherwise might. Methylation provides a method for controlling the longevity of mRNA molecules; it is desirable for some to be very short lived (where only a small amount of the encoded protein is required, as for an enzyme briefly needed) and for others to last longer (e.g., the mRNA coding for hemoglobin production in red blood cells, which live for about three months in the bloodstream).**

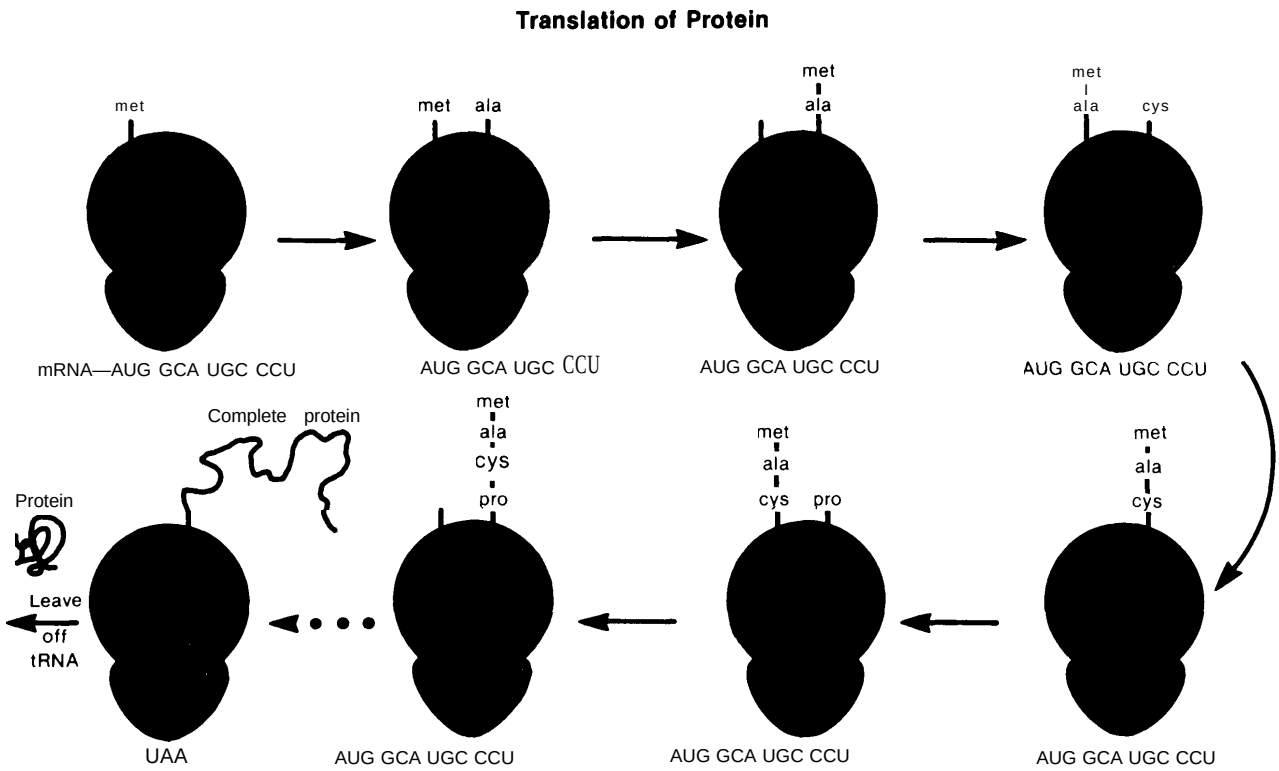
**The second major process involved in making use of the information encoded in the DNA is** translation, This takes place after mRNA is transcribed from DNA and then transported from the nucleus into the cytoplasm. In translation the information encoded in mRNA is decoded (translated) into protein by ribosomes. Ribosomes are complex structures within the cell that serve as the sites of protein synthesis, and they are composed of a number of different proteins combined with several different RNA molecules. On ribosomes, amino acids are joined one at a time to form a growing polypeptide chain. These individual amino acids are brought to the ribosome by transfer RNAs (tRNAs). Each different amino acid is brought

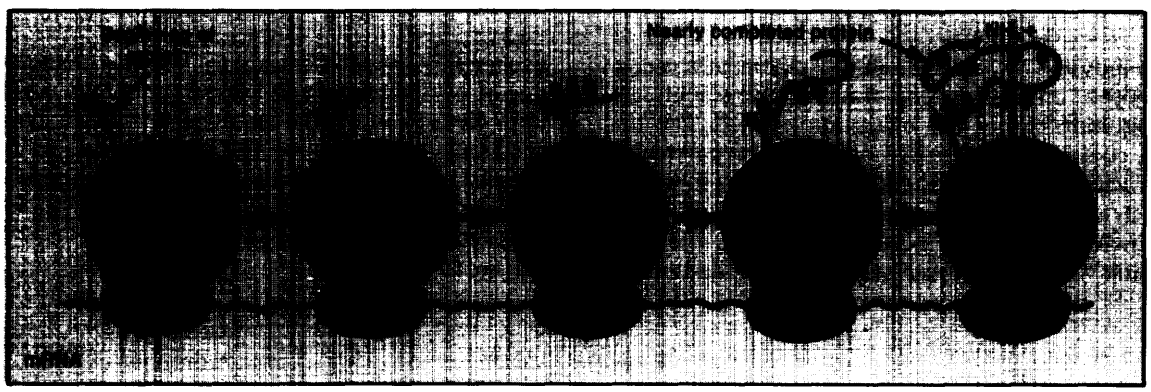
**Gene Splicing**




SOURCE: Office of Technology Assessment, adapted from Stanbury, et al., 1983,

to **the ribosome by a specific tRNA, which has a recognition site at one end specific for that amino acid, and a recognition site at the other end specific for the mRNA coding sequence that calls for the particular amino acid. These specific coding sequences in mRNA occur in a linear chain, and the amino acids added to the growing polypeptide as the mRNA moves along the ribosome reflect the linear sequence encoded in the master DNA region (gene) in the nucleus. Proteins produced by translation of messenger RNAs can begin their lives as enzymes involved in specific chemical reactions in the cell, or the proteins can be moved around or modified so that they become part of the surface of the cell, part of the cell's skeleton, or perform some other function.**



tRNA translates from mRNA into protein, with ribosomes acting as the conveyor belt to allow this process

SOURCE. Office of Technology Assessment.