20.22: Transcription and Translation

Although DNA contains the necessary instructions for synthesizing all the proteins necessary for the functioning of a cell, it does not take part directly in the synthesis itself. Sections of the DNA chain are first copied into a type of RNA called **messenger RNA**, mRNA. This process is known as **transcription**. In transcription, RNA polymerase opens up DNA and uses the base pair sequence of one of the DNA strands to synthesis a molecule of mRNA which is complementary to the **template strand.** The other strand is referred to as the **coding strand**, as it has the same sequence as the mRNA molecule formed. The synthesis of mRNA is governed by promoter sequences in the DNA, as well as binding of protein factors that can either promote or repress transcription. Such control is necessary for a cell produce the correct proteins at the correct time.

The mRNA molecules differ from DNA in three ways:

1 RNA is generally found in a single strand form, instead of the double helix structure of DNA.

2 RNA has a hydroxyl group ($-\ddot{\underset{\cdot\cdot}{O}}-H$) at the 2' carbon, wheras DNA simply has a hydrogen.

3 The base uracil (U) replaces thymine (T).

All three differences are displayed in Fig $20.22.1$ Another aspect of mRNA molecules is that they are also considerably smaller than DNA, containing the blueprints for only a few proteins at most.

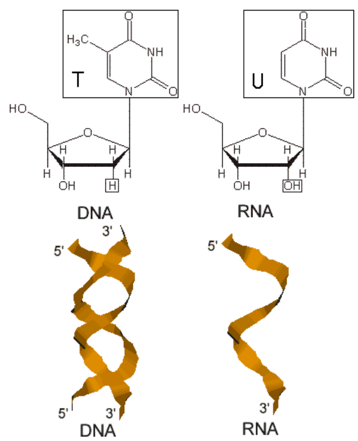

Figure $20.22.1$ The three main differences between DNA and RNA. RNA is single stranded, RNA has an -OH group at the 2' carbon, and uracil takes the place of thymine.

As the name implies, mRNA molecules are used to transport their coded instructions from the nucleus of the cell, where the DNA is situated, to the **ribosomes**, where the process of protein synthesis actually takes place.

When an mRNA molecule reaches a ribosome, a process called **translation** takes place in which the base sequence on the mRNA molecule is used to create a protein using the codon code. In translation, each codon on the mRNA base pairs with an **anticodon** base sequence on a RNA molecule called **transfer RNA**, tRNA. Each tRNA molecule is bound to the amino acid. Thus, the codon UUA will pair with the anticodon of the tRNA bound to leucine. The synthesis of the protein itself is performed by the ribosome, which is a protein-RNA complex, but unlike other enzymes, the catalytic activity is provided by the RNA portion, not the protein. The ribosome is thus sometimes referred to as a ribozyme, to distinguish it from the usual concept of any enzyme with protein based catalytic activity. Figure $20.22.2$presents this process as a cartoon.

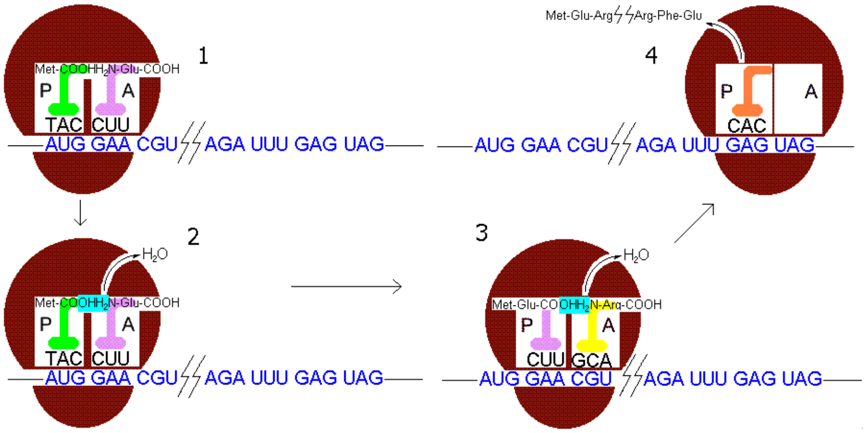

Figure 20.22.2 The synthesis of protein in the ribosome. 1) mRNA binds to the ribosome. The AUG start codon sits in the P or peptide site on the ribosome, and binds a tRNA with Met bound to it. The second codon, GAA in this example, binds a tRNA with Glu bound in a second site, the A or aminoacyl site. 2)The ribosome catalyzes the formation of a peptide bond between the amino acids in the P and A sites, so that the dipeptide is now attached to the tRNA in the A site. 3)The tRNA with the dipeptide moves to the P site and another tRNA brings the next amino acid into the A site. Another peptide bond is formed between the second and third amino acids. 4)This process continues until a stop codon on the mRNA enters the A site. Then the mRNA and the new protein are released from the ribosome and the protein is free to fold into its native structure.

In the cartoon, the brown structure represents the ribosome, the blue letters represent mRNA and its base sequence, the colored hooks represent tRNAs, and amino acids are represented by their three letter abbreviations. mRNA binds into the ribosome, which finds a start codon at which to begin translating. This begins with Methionine, which is bound to the tRNA which recognizes the AUG codon. The next tRNA enters in at the A site. The ribosome catalyzes the condensation reaction between the carboxyl end of methionine and the amino end of glutamate. The dipeptide is now bound to the tRNA in the A site. The tRNA for methionine shifts to the exit site and leaves the complex, while the dipeptide and bound tRNA move to the P site. The next activated tRNA, meaning the tRNA has an amino acid bound to it, enters the A site, and the process repeats until a stop codon is reached.