## 10.3 Transcription

**Learning objectives**

By the end of this section, you will be able to:

- *Explain the central dogma*
- *Explain the main steps of transcription*
- *Describe how eukaryotic mRNA is processed*
- *Be prepared to define and explain all bolded terms*

In both prokaryotes and eukaryotes, DNA contains the information necessary for the cell to build proteins. Most structural components of the cell are made up, at least in part, by proteins. Virtually all the functions that a cell carries out are completed with the help of proteins. In order to make proteins, the DNA is "read" or **transcribed** into an mRNA molecule. The mRNA then leaves the nucleus and provides the information necessary to synthesize the protein through a process called **translation**. This section will focus on the details of transcription.

### The Central Dogma: DNA Encodes RNA; RNA Encodes Protein

The flow of genetic information in cells from DNA to RNA to protein is described by the **central dogma** (Figure 10.20). The central dogma states that genes specify the sequences of RNAs, which in turn specify the sequences of proteins. Recall, that a gene is a functional segment of DNA that provides the genetic information necessary to build a protein.

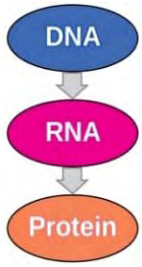


Figure 10.20 The central dogma states that DNA encodes RNA, which in turn encodes protein. (credit: Fowler et al. / Concepts of Biology OpenStax)

The copying of DNA to mRNA is relatively straightforward. During transcription, mRNA is synthesized with the help of many enzymes. RNA nucleotides complementary base pair with DNA nucleotides forming the RNA transcript. The translation to protein is more complex and will be discussed in the next section. Before taking a closer look at the process of transcription, let's first review the three types of RNA introduced in section 10.1: mRNA, tRNA, and rRNA.

### Types of RNA

As mentioned, ribonucleic acid, or RNA, is mainly involved in the process of protein synthesis. RNA is usually single-stranded and is comprised of nucleotides that are linked by phosphodiester bonds. A nucleotide in the RNA chain contains the sugar ribose, one of the four nitrogenous bases (adenine, uracil, guanine, and cytosine), and a phosphate group. There are three major types of RNA: messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA).

*Messenger RNA*

The first type, **messenger RNA** (mRNA), carries the message encoded in the DNA on how to build proteins (Figure 10.21). If a cell needs to synthesize a certain protein, the gene for this protein "turns on" and the messenger RNA is transcribed.

*Ribosomal RNA*

**Ribosomal RNA** (rRNA) is a major constituent of ribosomes (Figure 10.21). The rRNA ensures the proper alignment of the mRNA and the ribosomes. The ribosome's rRNA also has an enzymatic activity and catalyzes peptide bond formation between two aligned amino acids.

*Transfer RNA*

**Transfer RNA** (tRNA) is one of the smallest of the four types of RNA, usually 70–90 nucleotides long. It carries the correct amino acid to the site of protein synthesis within the ribosome(Figure 10.21). It base-pairs with the mRNA and allows for the correct amino acid to insert itself in the polypeptide chain.

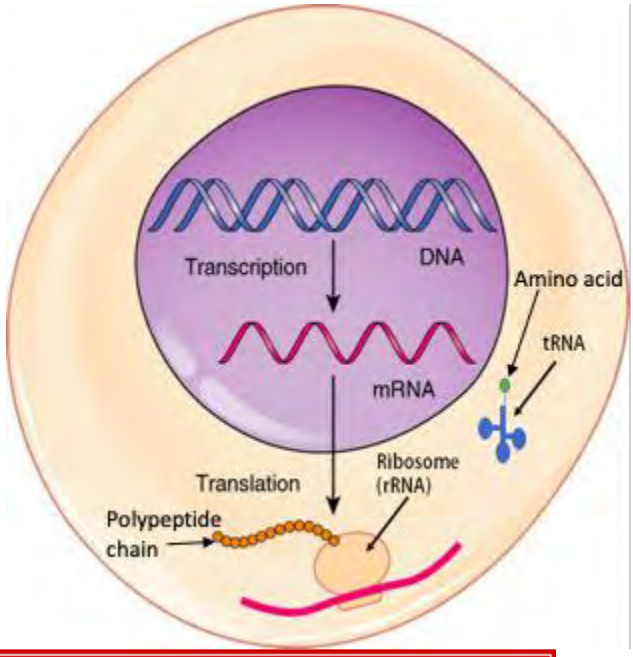


Figure 10.21 A eukaryotic cell showing mRNA, rRNA, and tRNA. (credit: Modified by Elizabeth O'Grady original work of Betts et al./ Anatomy and Physiology OpenStax)

**Check your knowledge**

In the following list, determine if each is a characteristic of rRNA, mRNA, tRNA.

- Carries code from DNA
- Carries the amino acid
- Made in the nucleolus
- Joins enzymes to form the ribosome
- Found in cytoplasm

Distinguish the difference between transcription and translation.

*Answers: mRNA, tRNA, rRNA, rRNA, all are found in the cytoplasm during translation.*

*Transcription must occur before translation. In transcription, DNA is coded into mRNA. The mRNA is then coded into an amino acid sequence in translation.*

**Transcription: from DNA to mRNA**

Both prokaryotes and eukaryotes perform fundamentally the same process of transcription, with one very important difference. In eukaryotes, transcription occurs in the membrane-bound nucleus. In prokaryotes, transcription occurs in the nucleoid region; recall that prokaryotes lack membrane bound organelles. Once the mRNA is formed in eukaryotic cells it must be transported to the cytoplasm. Because the mRNA of prokaryotes does not need to be transported anywhere, translation can immediately follow.

In both prokaryotes and eukaryotes, transcription occurs in three main stages: initiation, elongation, and termination.

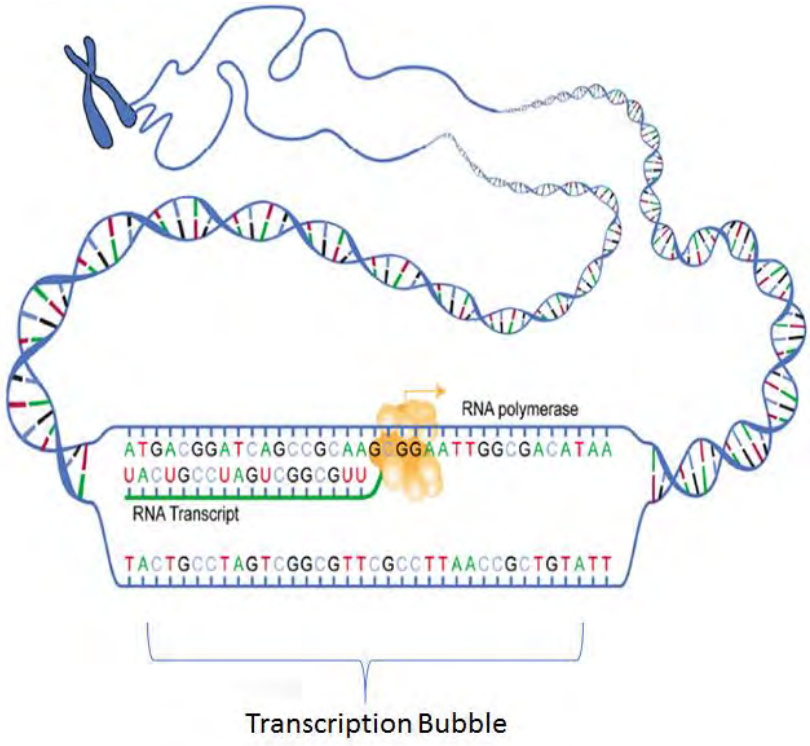


Figure 10.22 Transcription: from DNA to mRNA. (credit: Betts et al. / Anatomy and Physiology OpenStax)

*Initiation*

Transcription requires a small part of the DNA double helix to partially unwind. The DNA must unwind to allow enzymes and additional proteins to access specific genes which will then be used to make mRNA. The region of the DNA that is unwound is called the **transcription bubble** (Figure 10.22). Several proteins and enzymes bind to a region at the beginning of the gene called a **promoter**, a particular sequence of nucleotides that triggers the start of transcription (Figure 10.23). In most cases, promoters exist upstream, or in front of, the genes they regulate. The specific sequence of a promoter is very important because it determines whether the corresponding gene is transcribed all of the time, some of the time, or hardly at all.