



▲ **FIGURE 4-1 Overview of four basic molecular genetic processes.** In this chapter we cover the three processes that lead to production of proteins (**1–3**) and the process for replicating DNA (**4**). Because viruses utilize host-cell machinery, they have been important models for studying these processes. During transcription of a protein-coding gene by RNA polymerase (**1**), the four-base DNA code specifying the amino acid sequence of a protein is copied into a precursor messenger RNA (pre-mRNA) by the polymerization of ribonucleoside triphosphate monomers (rNTPs). Removal of extraneous sequences and other modifications to the pre-mRNA (**2**), collectively known as *RNA processing*, produce a functional mRNA, which is transported to the

cytoplasm. During translation (**3**), the four-base code of the mRNA is decoded into the 20-amino acid “language” of proteins. Ribosomes, the macromolecular machines that translate the mRNA code, are composed of two subunits assembled in the nucleolus from ribosomal RNAs (rRNAs) and multiple proteins (*left*). After transport to the cytoplasm, ribosomal subunits associate with an mRNA and carry out protein synthesis with the help of transfer RNAs (tRNAs) and various translation factors. During DNA replication (**4**), which occurs only in cells preparing to divide, deoxyribonucleoside triphosphate monomers (dNTPs) are polymerized to yield two identical copies of each chromosomal DNA molecule. Each daughter cell receives one of the identical copies.

In this chapter, we first review the basic structures and properties of DNA and RNA. In the next several sections we discuss the basic processes summarized in Figure 4-1: transcription of DNA into RNA precursors, processing of these precursors to make functional RNA molecules, translation of mRNAs into proteins, and the replication of DNA. Along the way we compare gene structure in prokaryotes and eukaryotes and describe how bacteria control transcription, setting the stage for the more complex eukaryotic transcription-control mechanisms discussed in Chapter 11. After outlining the individual roles of mRNA, tRNA, and rRNA in protein synthesis, we present a detailed description of the components and biochemical steps in translation. We also consider the molecular problems involved in DNA repli-

cation and the complex cellular machinery for ensuring accurate copying of the genetic material. The final section of the chapter presents basic information about viruses, which are important model organisms for studying macromolecular synthesis and other cellular processes.

4.1 Structure of Nucleic Acids

DNA and RNA are chemically very similar. The primary structures of both are linear **polymers** composed of **monomers** called **nucleotides**. Cellular RNAs range in length from less than one hundred to many thousands of nucleotides. Cellular DNA molecules can be as long as several