

## RNA

The three major types of ribonucleic acid in cells are called messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA). Although all three types occur as single polyribonucleotide strands, each type has a characteristic range of molecular weight and sedimentation coefficient (Table 12-3). Moreover, each of the three major kinds of RNA occurs in multiple molecular forms. Ribosomal RNA of any given biological species exists in three or more major forms, transfer RNA in as many as 60 forms, and messenger RNA in hundreds and perhaps thousands of distinctive forms. Most cells contain 2 to 8 times as much RNA as DNA.

In bacterial cells, most of the RNA is found in the cytoplasm, although some is noncovalently attached to DNA during its formation in the transcription process (page 917). In eukaryotic cells the various forms of RNA have a distinctive intracellular distribution. In the liver cell approximately 11 percent of the total RNA is in the nucleus, about 15 percent in the mitochondria, over 50 percent in the ribosomes, and about 24 percent in the cytosol. Like mitochondrial DNA, mitochondrial rRNAs and tRNAs differ from the extramitochondrial forms (page 951). RNA is present in some viruses discussed later in this chapter.

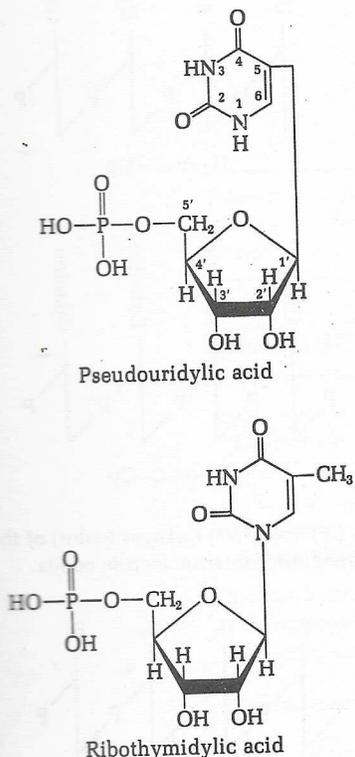
## Messenger RNA

Messenger RNA contains only the four major bases. It is synthesized in the nucleus during the process of transcription, in which the sequence of bases in one strand of the chromosomal DNA is enzymatically transcribed in the form of a single strand of mRNA; some mRNA is also made in the mitochondria. The sequence of bases of the mRNA strand so formed is complementary (page 918) to that of the DNA strand being transcribed. After transcription, the mRNA passes into the cytoplasm and then to the ribosomes, where it serves as the template for the sequential ordering of amino acids during the biosynthesis of proteins (pages 931 and 958). Although mRNA makes up only a very small part of the total RNA of the cell (Table 12-3), it occurs in many distinctive forms which vary greatly in molecular weight and base sequence. Each of the thousands of different proteins synthesized by the cell is coded by a specific mRNA or segment of an mRNA molecule.

Messenger RNAs of eukaryotic cells are distinctive in containing a long sequence of about 200 successive adenylate residues at the 3' end, which apparently plays a role in the processing or transport of mRNA from the nucleus to the ribosomes (page 919).

Figure 12-13

Two unusual nucleotides found in tRNAs. In pseudouridylic acid the N-glycosyl linkage is at position 5 of uracil, rather than the usual position 1. Ribothymidylic acid is unusual in that thymine is normally present in DNA but not in RNA.



## Transfer RNAs

Transfer RNAs are relatively small molecules that act as carriers of specific individual amino acids during protein synthesis on the ribosomes. They have molecular weights in the range of 23,000 to 28,000 and sedimentation coefficients (page 175) of about 4S. They contain from 75 to 90 nucleotide units. Each of the 20 amino acids found in proteins has at least one corresponding tRNA, and some have multiple tRNAs. For example, there are five distinctly different tRNAs specific for the transfer of leucine in *E. coli* cells. Moreover, there are different types of tRNAs for a given amino acid in the mitochondria and in the cytoplasm of eukaryotic cells. Many different tRNAs have been isolated from different kinds of cells.

Besides the major purine and pyrimidine bases transfer RNAs characteristically contain a rather large number of the rare bases, up to 10 percent of the total. In addition, tRNAs also contain some unusual nucleotides, e.g., pseudouridylic acid and ribothymidylic acid (Figure 12-13). Transfer RNA molecules share other identifying features. At one end of the polynucleotide chain all tRNAs contain a terminal guanylic acid residue; at the other end all tRNAs contain the terminal sequence cytidylic-cytidylic-adenylic (C-C-A). The 5'-hydroxyl group of the terminal adenylic residue is linked to the 3'-hydroxyl of the preceding cytidylic residue by a phosphodiester bridge. A free hydroxyl group of the terminal adenylic residue is enzymatically acylated with its specific  $\alpha$ -amino acid to yield the charged form of tRNA, namely, aminoacyl-tRNA. This amino acid residue is enzymatically transferred to the end of the growing polypeptide chain on

the surface of the ribosome during protein biosynthesis (Chapter 33).

Further details of the structure and function of tRNAs are provided below and in Chapter 33 (page 929).

### *Ribosomal RNA*

Ribosomal RNA (rRNA) constitutes up to 65 percent of the mass of ribosomes. It can be obtained from *E. coli* ribosomes in the form of linear, single-stranded molecules that appear in three characteristic forms, sedimenting at 23S, 16S, and 5S, respectively; these three forms differ in base ratios and sequences. In eukaryotic cells, which have larger ribosomes than prokaryotes, there are four types of rRNA; 5S, 7S, 18S, and 28S. Although rRNAs make up a large fraction of total cellular RNA, their function in ribosomes is not yet clear. A few of the bases in rRNAs are methylated.