I. Differences between RNA and DNA

RNA has **ribose** (DNA has 2'-deoxyribose): prevents regular double-helix

RNA has **uracil** instead of thymine: deamination of cytosine looks like uracil; enzymes recognize uracil in DNA and remove it

RNA is **single-stranded**: it can adopt **secondary** structure that includes regions that are double-stranded; allows for diverse functions of RNA

II. Types of RNA (by function)

messenger RNA. DNA is in the nucleus, but protein synthesis occurs in the cytoplasm. The DNA sequence of a gene is copied into an RNA sequence by transcription; the RNA copy of a gene is the **mRNA**. About 2-3% of the total RNA in a cell.

transfer RNA. There is no chemical basis for amino acids to recognize RNA. **tRNA** is the adaptor. 75-90 nt RNAs with extensive secondary and tertiary structure. After transcription they are processed by splicing and by modifications to the nucleotides. ~15% of the RNA in a cell.

ribosomal RNA. Protein synthesis occurs on ribosomes, which are complexes of polypeptides and special **rRNA**s. rRNA constitutes ~80% of the RNA in a cell. rRNAs demonstrate several exceptions to themes in molecular genetics:

Not all enzymes are proteins: rRNA performs the catalytic functions of the ribosome.
Not all genes encode polypeptides: rRNA and tRNA genes encode RNA molecules.
Not all genes occur only once in the genome: rRNA genes occur in clusters of dozens to hundreds of tandemly repeated copies, called **rDNA**. In humans, rDNA is on chromosomes 1, 13, 14, 15, 21, and 22. Recombination between rDNA can result in translocations.

There are various other small nuclear RNAs (**snRNAs**), which associate with proteins to make **snRNP**s (small ribonucleoproteins, "snurps"). Involved in splicing. Recently, micro-RNAs (**miRNA**s) have been discovered. These function in gene regulation.

III. Comparison of replication and transcription

	REPLICATION	TRANSCRIPTION
enzyme	DNA polymerase	RNA polymerase
template	DNA (both strands)	DNA template strand
start site	origin of replication	promoter
substrates	dNTPs	NTPs
primer	required	NOT required
direction	5' to 3'	5' to 3'
product	double-stranded DNA	single-stranded RNA

IV. Transcription

Transcription is the process of making an RNA copy of a gene - the **messenger RNA** (**mRNA**). A protein sequence is encoded by one strand of the double-stranded DNA helix. We will refer to this as the **coding strand** (Griffiths calls it the non-template strand). To make an RNA copy of the coding strand, RNA polymerase must use the complement as a template – the **template strand**:

We refer to the coordinates of a gene relative to the coding strand, which runs from 5' to 3'. Transcription starts at position +1. The nucleotide to the 5' side is -1; the 5' direction is said to be **upstream**, and the 3' direction **downstream**.

There are three different RNA polymerase enzymes in eukaryotic cells:

RNA polymerase I synthesizes rRNA.
RNA polymerase II synthesizes mRNA.
RNA polymerase III synthesizes tRNA (and some other RNA genes).

V. Promoters

The promoter is the DNA sequence that tells RNA polymerase where to begin transcription. They can vary in sequence, but usually closely match a **consensus** (see Figure 10-8b).

In *E. coli*, there is a TATAAT consensus sequence at about -10; it is sometimes called the **Pribnow box**. Eukaryotic promoters often have a similar sequence at that location, called the **TATA box**, and another important sequence, the **CAAT box**, at about –80.

Some promotors may be "stronger" than others, causing RNA polymerase to initiate transcription there more frequently than at other genes.

VI. Initiation, elongation and termination

In *E. coli*, initiation of transcription requires the **sigma subunit** of RNA polymerase. Initiation in eukaryotes is complex, and involved many **transcription factors**.

Termination depends on both proteins and DNA sequences, and perhaps DNA structures (the single-stranded DNA created to allow transcription may adopt secondary structure).

Note that DNA replication begins at origins of replication scattered throughout the chromosome; replication proceeds until the entire chromosome has been replicated. Transcription, however, occurs in relatively short regions along a chromosome. Thus, while 100% of the human genome is replicated in each S phase, less than 20% is ever transcribed. An individual cell transcribes probably only a few percent of the genome. However, there is still much more RNA in a cell than DNA, because of the high levels of rRNA and tRNA.