Protein Synthesis

I. From DNA to Proteins
   a. The amino acid sequences of polypeptide chains—the structural units of proteins—are encoded in genes
   b. The process requires two steps, transcription and translation.
      i. Transcription: First stage of protein synthesis. The code from DNA is used to make RNA. The transcript’s base sequence is complementary to that of the DNA template.
      ii. Translation: Stage of protein synthesis in which an mRNA’s base sequence becomes converted to a sequence of particular amino acids in a new polypeptide chain.
   c. Three classes of RNA (ribose nucleic acids)
      i. Transcription of most genes produces Messenger RNA (mRNA), which is the only class of RNA that carries protein-building instructions.
         1. Transcription: process in which the code from DNA is used to make RNA.
      ii. Transcription of some other genes produces Ribosomal RNA (rRNA), a major component of ribosomes, the structural units upon which polypeptide chains are assembled.
      iii. Some genes are transcribed as Transfer RNA (tRNA), which delivers amino acids one by one to a ribosome in the order specified by mRNA.
   d. RNA molecules are almost like a single strand of DNA.
      i. RNA consists of only four types of nucleotides, each with a five-carbon sugar (ribose), a phosphate group, and a base.
      ii. Three types of bases—adenine, cytosine, and guanine—are the same as in DNA, but in RNA the fourth base is uracil, not thymine.
         1. Cytosine pairs with Guanine
         2. Adenine pairs with uracil (or thymine)

II. Transcription
   a. During transcription, RNA’s are made by laying down nucleotides complementary to those on the DNA.
      i. Transcription is initiated at a promoter, a base sequence in DNA that signals the start of a gene.
      ii. Most eukaryotic genes contain one or more introns, base sequences that must be removed before a pre-mRNA itself gets translated.
         1. The introns intervene between exons, that parts that remain in the mRNA when it gets translated into proteins.

III. The Genetic Code
   a. The protein building “words” in the mRNA are read three bases at a time, as triplets
      i. MRNAs are the only molecules that carry protein-building instructions from DNA into the cytoplasm.
ii. Base triplets are called **codons**.

iii. There are $4^3$ or 64 **codons**, but most of the twenty kinds of amino acids correspond to more than one **codon**.
   1. **AUG** codes for methionine and also is an initiation **codon**, a START **codon**.
   2. **UAA, UAG, and UGA** do not correspond to amino acids, but are STOP **codons**.

b. **tRNA** has an area on it called an **anticodon**, a nucleotide triplet that can base-pair with a **codon**.
   i. When **tRNAs** bind to the **codons**, they automatically position their attached amino acids in the order specified by **mRNA**.
   ii. Before anticodons interact with codons of an mRNA strand, that strand must bind to specific parts of the surface of ribosomes.
      1. The two subunits of the ribosomes are assembled inside the nucleus from rRNA and protein components.

IV. **Translation**

a. The protein-building code built into **mRNA** transcripts of DNA become translated at intact ribosomes in the cytoplasm and translation proceeds through three stages
   i. **Initiation**
      1. A particular **tRNA** that can start transcription and an **mRNA** transcript are both loaded onto a ribosome.
         a. **AUG**, the start codon for the transcript, matches up with this **tRNA’s anticodon**.
   ii. **Elongation**
      1. A polypeptide chain is assembled as the **mRNA** passes between two ribosomal subunits.
      2. Enzymes on the ribosomes join individual amino acids together in a sequence dictated by the codons in the **mRNA**.
   iii. **Termination**
      1. A STOP **codon** in the **mRNA** moves onto the platform, and no **tRNA** has a corresponding anticodon.
      2. Proteins called release factors bind to the ribosome, triggering enzyme activity that detaches the **mRNA** and the chain from the ribosome.

b. New polypeptide chains
   i. Usually join the cytoplasmic pool of free proteins
   ii. Other enter the ribosome-studded, flattened sacs of rough ER