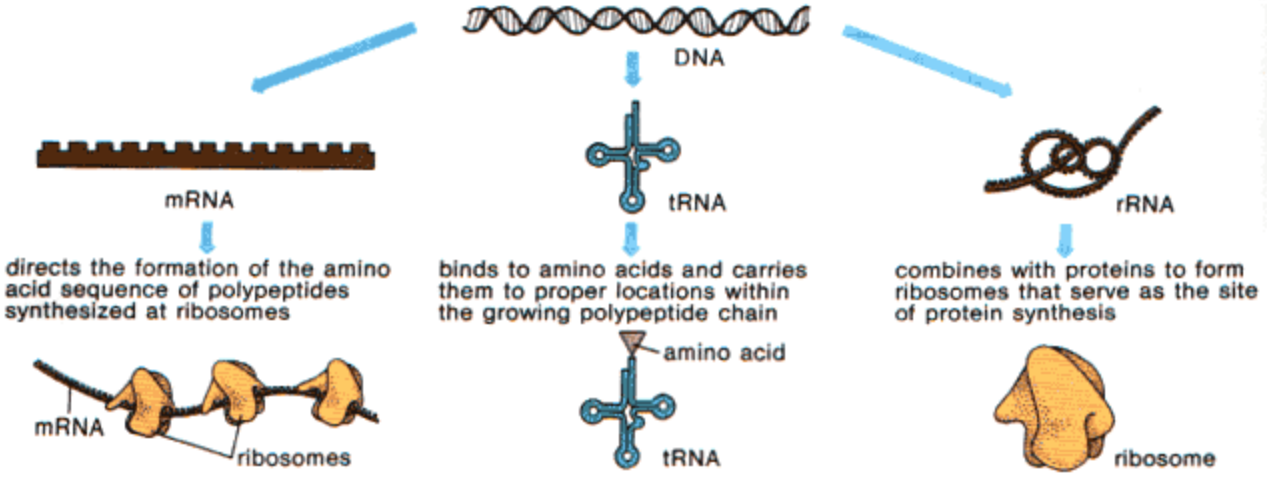
Chapter 10 – Information Transfer and Protein Synthesis

1. **DNA** – genetic material. Known as the Master Molecule of life. The chemical link between generations
   DNA controls RNA synthesis, which in turn, controls protein synthesis

2. **Ribosomes** – the organelle where protein synthesis occurs. Each consists of a small and large subunit
   The two mature subunits can join to form the intact ribosome to synthesize proteins
   Ribosomes split back up after protein synthesis

3. **The Genetic Code** – the molecular code of life. Researchers were able to decipher the meaning of certain genes
   Code – a system or symbols to store information. DNA stores information in 4 nucleotides (A, G, C, T)
   A genetic code would require at least 20 different messages – 1 for each amino acid
   Most genetic information use 3 different letters, making 64 different combinations (CAT, GCT, etc.)

4. **RNA** – the molecule that "carries out the instructions given by the DNA"
   DNA doesn't leave nucleus. RNA is synthesized in nucleus, moves into cytosol to carry out instructions
   While DNA uses the letters A, T, G, and C, RNA uses A, U, C, G
   mRNA – Messenger RNA – Directs the formation of the amino acid sequence of polypeptides
      The DNA information is copied into strands of mRNA, which is then moved to other parts of cell
      Responsible for carrying instructions for protein synthesis to the ribosomes
   tRNA – Transfer RNA – binds to amino acids/carries them to their proper locations on polypeptide chain
   rRNA – ribosomal RNA – combines with proteins to form ribosomes



   Transcription – RNA synthesis
   Codon – an RNA triplet – The first one discovered was UUU
      Theoretically, there are 64 triplet of RNA total. However, only 60 of them symbolize amino acids
      The codon AUG signals the ribosomes to begin attaching additional codons
      The ribosomes will keep attaching codons until it hits a terminator codon (UAA, UAG, or UGA)
   RNA Synthesis – RNA is synthesized directly next to the DNA – DNA information is copied onto RNA
      Only 1 strand of DNA, the coding strand, is used to synthesize RNA
      Like DNA synthesis, the nucleotides must match up (A – T, C – G)
         However, in RNA, T is replaced with U (uracil)

DNA	RNA
A	U
G	C
C	G
T	A

   RNA Polymerase – the enzyme that catalyzes the reaction to synthesize RNA
   Stages of RNA Synthesis – Initiation, elongation, termination
      Initiation – RNA polymerase attaches to a site (promoter region)

Called the promoter region because it "promotes" RNA synthesis
Unwinds the DNA so that it can be copied

Elongation – RNA is synthesized from template of the coding strand
Enzymes moves along the coding strand, reading and copying it

Termination – RNA polymerase reaches the end of gene or coding region
RNA is released and RNA polymerase falls off

Primary RNA Transcript – a fancy name for the newly synthesized RNA

Transcription in Prokaryotes - Only 1 RNA polymerase as compared to 3 in eukaryotes
Overall process the same
The Primary RNA Transcript can have 200,000 nucleotides. Average in humans is 5000
After they get to the ribosomes, only 1000 nucleotides remain
Before they leave the nucleus, they undergo processing.

Processing of the Primary RNA Transcript – All three types of RNA undergo processing
Below describes the processing of mRNA

1. A cap made of methyl-guanine (mG) is placed on the starting end of mRNA
2. 100 – 2000 Adenine nucleotides are added to the other end to form a poly-A-Tail
   The cap and the poly-a-tail protect mRNA from harmful enzymes in the cytosol
   The tail may also help move the transport through the nuclear membrane
   The cap helps mRNA attach to a ribosome and being protein synthesis
3. **Splicing** - Parts of the transcript are cut out and the cut ends joined
   Introns – the parts that are removed – represent the non-coding regions of DNA
   There are an average of 4000 introns removed in human RNA
   Exons – the parts that remain after splicing – represents the coding regions
   The non-coding regions are unnecessary
   The two steps of splicing
   One end of intron is cut, curls up
   The two exons are joined, and the intron is released

Splicing normally requires several additional enzymes, but sometimes the RNA can catalyze itself
After processing, the mature mRNA moves out of the nucleus to the ribosomes

tRNA – spliced, several nucleotides are chemically modified, and molecule is folded into 3d figure
Anticodon – nucleotide tiplet that is complementary to a mRNA codon
Used to match up with mRNA and amino acid
The final structure is folded into the shape of a 3 dimensional L

rRNA – is not involved in coding. Involved in creating the ribosomes themselves
Formed in a chromatin rich area of nucleus, the nucleolus
rRNA is synthesized, processed, and combined with 70 proteins to form ribosomes
Recognition Sites – areas where tRNA and mRNA can bind during protein synthesis

5. **Protein Synthesis** – the making of new proteins. Generally takes place in the ribosomes

Translation – fancy name for protein synthesis. Codon info is translated into amino acid chains
tRNA gets the amino acid and uses mRNA's instructions to make the proper protein
RNA Charging - tRNA binds with 1 of 20 different amino acids and one of 20 different enzymes
Each ribosome contains two binding sites where mRNA and rRNA are brought together
P Site – holds tRNA carrying the growing polypeptide chain
A Site – holds the tRNA carrying the next amino acid to be added to the chain
During translation, ribosome moves along the mRNA strand and reads 1 codon at a time
Stages of Translation – Initiation, Elongation, Termination
Initiation and Elongation require energy supplied by GTP, similar to ATP
Initiation – the mG cap of mRNA attaches to ribosome. Leads the mRNA through the ribosome
The codon AUG signals the start of protein synthesis
Methionine – code name AUG, the same as the initiation codon
A methionine charged tRNA pairs with AUG at the P site
Elongation – Amino acids are added one at a time
tRNA binds to A site
Polypeptide chain and new amino acid form A site form a polypeptide bond at P Site
tRNA leaves the ribosome, and moves one codon along the mRNA, process repeats
Termination – terminates when codon reaches UAA, UAG, or UGA at the A site
A special protein binds to stop codon in the A site, completed polypeptide chain released
Correcting Translation Errors – sometimes nucleotide sequences are misread.
Reading Frame – the grouping of bases into codons.
Proof reading is done by an enzyme. Errors include repeated segments, coding backwards, etc.

6. Transport and Modification of Proteins

Proteins need to be moved somewhere. Moved by the ER (Endoplasmic Reticulum – see ch.6)
First few amino acids synthesized tell the ribosomes where to send the cell
The finished protein is sent into the inner ER, where it's sent to Golgi apparatus and sealed in vesicle
These proteins can become part of membrane, or shipped out of the cell
Proteins may also be cut into smaller pieces or clipped before use by special enzymes
    Pepsin and Trypsin – two digestive enzymes that digest proteins in the diet

7. Other Important Information

DNA and RNA molecules are pretty much universal among all kingdoms of life
All cell functions are ultimately the result of the synthesis of a protein
Proteins are chains of amino acids in a (3D) shape. The shape determines the function of the protein
Nirenberg – adding mRNA from one type of cell increased protein synthesis in another type of cell
    Did experiment with synthesized mRNA molecules and radioactive nucleotides
    Out of the 20 tested, only 1 synthesized an amino acid. Synthesized phenylalanine
No one knows that introns do exactly. They may have been involved in the evolution of DNA from RNA
    Prokaryotes do not have introns, and protein synthesis takes place after transcription
    Prokaryotes had introns long ago, but they have been deleted through evolution
The first amino acid of every protein is phen, coded by the codon AUG
Polypeptide chain – a chain of amino acids - another name for a protein
There are 20 amino acids total we need, 8 of which our bodies cannot produce.
    Those 8 amino acids must be obtained from our diet