Overview of Gene Expression

- The information stored in DNA is in the form of specific sequences of nucleotides along the DNA strands.
- The DNA inherited by an organism leads to specific traits by dictating the synthesis of proteins.
- Proteins are the links between genotype and phenotype.
- Genes provide the instructions for making specific proteins.
- The bridge between DNA and protein synthesis is RNA.
- RNA is chemically similar to DNA, except that it contains ribose as its sugar and substitutes the nitrogenous base uracil for thymine.
    - An RNA molecule almost always consists of a single strand.
- In DNA or RNA, the four nucleotide monomers act like the letters of the alphabet to communicate information.
- The specific sequence of hundreds or thousands of nucleotides in each gene carries the information for the primary structure of a protein (***and what is the primary structure???***)
- To get from DNA, written in one chemical language, to protein, written in another, requires two major stages, ***transcription and translation***.
- During **transcription**, a DNA strand provides a template for the synthesis of a complementary RNA strand.
    - This process is used to synthesize any type of RNA from a DNA template.
- Transcription of a gene produces a **messenger RNA** (**mRNA**) molecule.
- During **translation**, the information contained in the order of nucleotides in mRNA is used to determine the amino acid sequence of a polypeptide.
    - Translation occurs at ribosomes (in the cytoplasm).
- The basic mechanics of transcription and translation are similar in eukaryotes and prokaryotes.
- Because bacteria lack nuclei, transcription and translation are coupled.
    - Ribosomes attach to the leading end of a mRNA molecule while transcription is still in progress.

- In a eukaryotic cell, almost all transcription occurs in the nucleus and translation occurs mainly at ribosomes in the cytoplasm.

- In addition, before the **primary transcript** can leave the nucleus it is modified in various ways during **RNA processing**
before the finished mRNA is exported to the cytoplasm.

- To summarize, genes program protein synthesis via genetic messenger RNA.

- The molecular chain of command in a cell is :

DNA ➔ RNA ➔ protein.

In the genetic code, nucleotide triplets specify amino acids

- If the genetic code consisted of a single nucleotide or even pairs of nucleotides per amino acid, there would not be enough combinations (4 and 16 respectively) to code for all 20 amino acids.

- Triplets of nucleotide bases are the smallest units of uniform length that can code for all the amino acids.

- In the **triplet code**, three consecutive bases specify an amino acid, creating 4^3 (64) possible code words.

- The genetic instructions for a polypeptide chain are written in DNA as a series of three-nucleotide words (AAT, TAG, CGG).

- During transcription, one DNA strand, the **template strand**, provides a template for ordering the sequence of nucleotides in an RNA transcript.

    - The complementary RNA molecule is synthesized according to base-pairing rules, except that uracil is the complementary base to adenine.

- During translation, blocks of three nucleotides, **codons**, are decoded into a sequence of amino acids.

- During translation, the codons are read in the 5'➔3' direction along the mRNA.
- Each codon specifies which one of the 20 amino acids will be incorporated at the corresponding position along a polypeptide.
- Because codons are base triplets, the number of nucleotides making up a genetic message must be three times the number of amino acids making up the protein product.
- The entire genetic code was deciphered by the mid 1960s.
  - 61 of 64 triplets code for amino acids.
  - The codon AUG not only codes for the amino acid methionine but also indicates the ***start*** of translation.
  - Three codons do not code for amino acids, but signal the termination of translation (UAA, UAG, UGA).
- The genetic code is *redundant* but not *ambiguous*.
  - There are typically several different codons that would indicate a specific amino acid.
  - However, any one codon indicates only one amino acid.
    - If you have a specific codon, you can verify the corresponding amino acid, but if you know only the amino acid, there may be several possible codons.
  - Codons synonymous for the same amino acid often differ only in the third codon position.

The genetic code must have evolved very early in the history of life

- The genetic code is nearly universal, shared by organisms from the simplest bacteria to the most complex plants and animals.
- In laboratory experiments, genes can be transcribed and translated after they are transplanted from one species to another.
- This has permitted bacteria to be programmed to synthesize certain human proteins after insertion of the appropriate human genes.
- This and other similar applications are exciting developments in biotechnology.
- The near universality of the genetic code must have been operating very early in the history of life.
- A shared genetic vocabulary is a reminder of the kinship that bonds all life on Earth.