

Notes for Workshop #1: DNA Structure, Transcription, & Translation

DNA (Deoxyribonucleic Acid) Structure:

- Structure determined by Watson and Crick in 1957- sugar and phosphate backbone with specific nitrogenous base pairing
- Composed of nucleotides, which each consist of a five carbon sugar, a phosphate group, and a nitrogenous base
 - Bases are separated into two groups - purines (adenine and guanine, both have double ring structure) and pyrimidines (thymine and cytosine, both have single ring structure)
 - Chargaff discovered number of purines = number of pyrimidines in all organisms → A&T pair together with 2 hydrogen bonds and C&G pair together with 3 hydrogen bonds (more stable)
- Chromosomes are formed as a single molecule of DNA coils around proteins (histones) to form chromatin. Histone proteins then form complexes of five called a nucleosome. Ultimately, coiling and supercoiling compacts the DNA 10,000 fold.
- Humans have 46 chromosomes, 3 billion base pairs total, in the human genome. These chromosomes are stored in the nucleus. Bacteria, however, are prokaryotes and do not have a nucleus or multiple chromosomes; they instead contain on circular chromosome within the cytoplasm of the cell.
- Antiparallel strands - 3' to 5' and 5' to 3'
- DNA Replication: Occurs prior to cell division. The DNA molecule “unzips” at the hydrogen bonds and each strand then acts as a template for the formation of complementary base pairs.
 - “Semiconservative” as half of the original strand is conserved.
 - Origin of replication= site where the DNA opens as helicase unwinds the strand. There are multiple origins of replication on a strand of DNA in order to increase efficiency (100-1,000)
 - DNA polymerases add new nucleotides to replicate the DNA strand. The new strand is added 5' to 3' while reading the old template 3' to 5'

RNA Structure:

- Like DNA, but single-stranded (not double-stranded), ribose sugar (not deoxyribose), and uracil instead of thymine
- Multiple forms: mRNA (messenger RNA- carries the code from the nucleus to the ribosome, long linear strand), tRNA (transfer RNA- binds to one of the 20 different amino acids and carries them to the ribosome for creation of a protein, coiled), rRNA (ribosomal RNA- makes up the ribosome along with associated proteins, coiled)

Central Dogma: DNA makes RNA makes proteins
(transcription) (translation)
in the nucleus in the cytoplasm

Genetic Code:

- DNA is read in groups of three bases, known as triplets. These are known as codons on mRNA and anticodons on tRNA.
 - Redundant but not ambiguous - multiple triplets codons code for the same amino acid, but no codon codes for multiple amino acids. Typically it is the 3rd nitrogen base that changes to code for the same amino acid (wobble). This helps protect against mutations.
- Start codon= AUG
- Stop codons= UAA, UAG, and UGA

Transcription:

- Only one strand (template strand) is transcribed
- Initiation- RNA polymerase II binds to a promoter region; unhooks the DNA and adds nucleotides to the 3' end of the growing DNA strand (copying 5' to 3', just like DNA polymerase)
- Elongation- Formation of RNA continues and the mRNA moves away from the DNA as it is produced. This allows a single gene to be transcribed many times simultaneously depending on the needs of the cell.
- Termination- Terminator sequences release the mRNA and the DNA strand reforms

RNA Modification:

- Alterations that occur before the RNA leaves the nucleus.
- Not all nucleotides code for a protein. There are noncoding regions within genes.
- Splicing- noncoding regions called introns (intervening segments) are cut from the expressed regions called exons.
- Alternative splicing- variations in introns and exons allow for different polypeptides to be made from the same section of mRNA.

Translation:

- Occur at the ribosomes. A ribosome consists of 2 subunits - P and A binding sites for tRNA. Ribosomes are constructed in the nucleolus, although complete assembly occurs in the cytoplasm.
- Conversion of the mRNA sequence to a sequence of amino acids
- Requires tRNA to transfer amino acids from the cytoplasm to the ribosomes (the site of protein synthesis).
- tRNA- one end is the amino acid attachment site, while the other is a series of base triplets called anticodons which bind by hydrogen bonds to codons. tRNA's can be used repeatedly.
- Same three steps as with transcription (see image below):
 - Initiation- begins at 5' end of the mRNA at the start codon of AUG.

- Elongation- codon recognition, peptide bond formation, and translocation (ribosome shifts to move down the strand).
- Termination- occurs at the stop codon. The ribosome lets go of the mRNA.
- Polysomes- many ribosomes read the same strand at the same time.

Proteins:

- Formed from amino acids which consist of an alpha carbon bonded to a side chain, an amine group, a carboxyl group, and a hydrogen atom. Two amino acids combine to form a dipeptide as dehydration synthesis forms a peptide bond between them.
- Protein Structure - four levels:
 - Primary- amino acid chain
 - Secondary- alpha helix and beta pleated sheet formed by hydrogen bonds
 - Tertiary- disulfide bridges and additional bonding (the protein folds on itself even more)
 - Quaternary- several polypeptides folded together (ex. hemoglobin contains four polypeptides)