Terms - Alphabetical

Alternative Splicing Some exons forming part of the mature mRNA, other exons doing so at other times, to form alternate amino acid sequences and therefore different proteins

DNA (Deoxyribonucleic acid): Genetic material of humans

Exons Sequences of DNA that translate into amino acid sequences for protein synthesis

Introns allow for alternative splicing, which in turn allows one gene to code for multiple transcripts and therefore serve multiple complex cellular functions.

Nucleic acids: long polymers composed of repeating nucleotides

Nucleotide: pentose sugar, phosphate and a nitrogenous base

Promoter Region A region of a DNA upstream from the gene that is **not transcribed** and that RNA polymerase binds to

RNA (Ribonucleic acid): Used to make genes into proteins

RNA Polymerase: An enzyme that transcribes DNA into mRNA.

Semi-conservative: Method of DNA replication where the original strands of DNA separate and act as a template for two new strands

Splicing introns are removed from the pre-mRNA by the spliceosome and exons are spliced back together.

Spliceosome removes introns from a transcribed pre-mRNA,

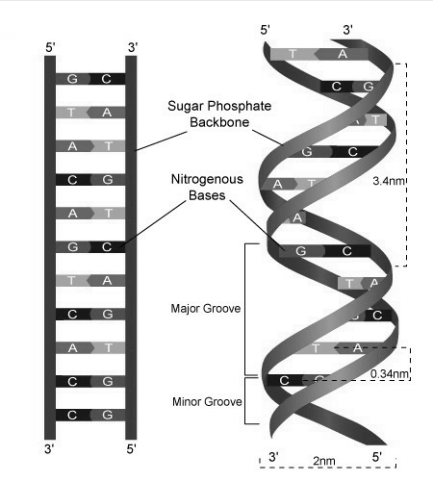
Terms - Alphabetical (cont)

Terminator Sequence A sequence of DNA at the end of a gene that causes mRNA molecule to form a hairpin loop, causing the polymerase to dissociate from DNA

Transcription: A Messenger RNA (mRNA) is made from a gene within DNA

Translation Using the mRNA to direct the production of a protein

DNA Structure



👉Double helix which is composed of 2 strands of nucleotides that are antiparallel

👉One strand runs 5' to 3' and the other strand runs in the opposite direction 3' to 5'

👉The sugar and phosphate make up the backbone while the bases make up the "-rungs" of the ladder.

Bases

Larger bases are called **purines** and have a double ringed structure: Adenine and Guanine
Smaller bases are called **pyrimidines** and have a single ringed structure: Cytosine and Thymine
For DNA

Bases (cont)

Adenine (A) <-> Thymine (T)
Cytosine (C) <-> Guanine (G)
Remember the pairs:
Apple on **T**rees
Car in **G**arage
For RNA
Adenine (A) <-> **Uracil (U)**
Cytosine (C) <-> Guanine (G)
Remember the pairs:
Apple are **U**nder
Car in **G**arage

DNA Replication

• The two strands of DNA that form the double helix DNA molecule are **complementary** to each other
• The hydrogen bonds that hold the base pairs together are **weak bonds** and are easy to separate
Simplified Steps in DNA replication
1. An enzyme called **helicase** unwinds the DNA. The hydrogen bonds between the base pairs are broken
2. DNA polymerase moves along each strand to unwound DNA and adds the correcr complementary nucleotides
3. Breaks in the sugar-phosphate backbone are sealed by an enzyme called **DNA ligase**
4. The two DNA molecules are identical to each other and to the original parent molecule
Note: DNA replication is semi conservative
• Mistakes can occur during replication. There are repair enzymes that work to fix this. Sometimes an error persists leading to a mutation, and to a genetic and phenotypic variability

DNA replication is semi conservative

DNA Replication is Semi-Conservative

• The parental DNA strand is used as a template to synthesize a new daughter stand
• This happens for both parental strands
• Therefore, after DNA replication you get two DNA molecules – each consisting of one parental strand and one daughter (newly synthesized) strand

DNA Mutations

How do cells deal with mutations?
Proofreading – Polymerase is able to recognize some mistakes that occur during replication
Repair enzyme – Enzymes that correct DNA mutations

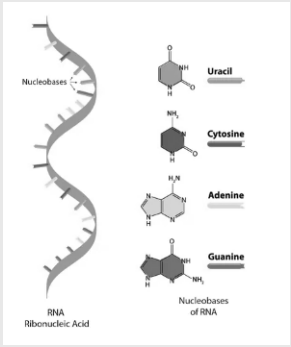
What if mutations still occur?
Apoptosis – programmed cell death
Immune cells – kill cancer cells

What is mutations still occur?
Disease

There are different types of DNA mutations
Substitution – The wrong base or bases are matched
Insertion – An extra base or bases are added in
Deletion – A base or bases are removed
Insertion and Deletion are the most harmful – results in frame-shift mutations (a change in multiple codons)

Causes:
Mistakes during replication
Transposition
Inherited mutations
Mutagens and Carcinogens
Viruses
Radiation
Chemicals
Cancer – usually two or more mutations in genes that code for repair enzymes, or genese that affect cell cycle

RNA



Single stranded nucleic acid molecule transcribed from a DNA gene sequence that codes for synthesis of a protein

Sugar-phosphate backbone

Types of RNA

Ribosomal (rRNA) Joins with proteins to form ribosomes

Messenger (mRNA) carries genetic information from DNA to the ribosomes (made in transcription)

Transfer (tRNA) transfers amino acids to a ribosome where they are added to a forming protein (used in translation)

Protein

End-products of gene expression – take a gene and make it a protein

Composed of subunits called amino acids

20 different amino acids in proteins (that are synthesized on ribosomes)

Central Dogma of Gene Expression

• The information contained in DNA is stored in blocks – genes
• The genes code for mRNA, which codes for proteins
• The proteins determine how a cell functions

Central Dogma of Gene Expression (cont)

• The path of information is DNA -> RNA -> Protein
• When gene sequences are used by the cell to make protein, called **gene expression**

Replication (DNA -> DNA)
Transcription (DNA -> RNA)
Translation (RNA -> protein)

Transcription Overview

• mRNA is made from a DNA template
• mRNA is processed before leaving the nucleus
• mRNA moves to the ribosomes to be read
• Transcriptions in both prokaryotes and eukaryotes has 3 stages: initiation, elongation, and termination

Transcription

• The complementary RNA nucleotide for each DNA nucleotide is as follows:
DNA <-> RNA

T A

C G

G C

A U

Transcription

Initiation
• RNA polymerase binds to a promoter region on DNA
• They help the polymerase locate the beginning of a gene
• Most mRNA molecules start with the codon AUG, which serves as the gene's starting point, corresponding to ATG on the coding strand.

Elongation

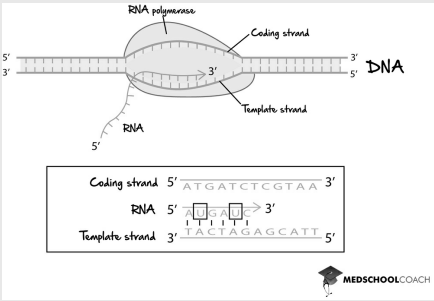
Transcription (cont)

• RNA polymerase adds complementary nucleotides to the template strand of the gene on DNA
• This produces the mRNA
• This process ensures that the mRNA sequence matches the order of nucleotides in the DNA coding strand, except RNA has uracil instead of thymine.
• RNA polymerase can only add nucleotides in the 5' to 3' direction, similar to DNA replication. ATP is needed for RNA polymerase to function.

Termination

• Transcription of a gene finishes when the polymerase enzyme encounters a terminator sequence.
• The mRNA dissociates and is now free to be translated by a ribosome
• DNA remains unchanged, and the mRNA is set for translation.

Transcription



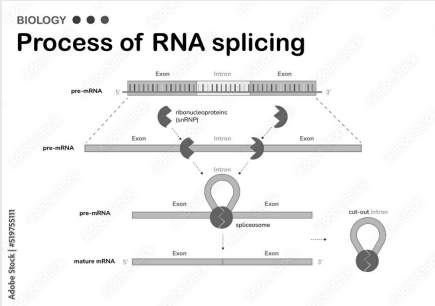
RNA Processing

• The freshly formed mRNA, known as the primary mRNA or primary transcript, undergoes three essential steps to transform into a mature mRNA that can only be used as a template for translation
• To shield the RNA from degradation, a 5' cap and a 3' poly-A tail are added.

RNA Processing (cont)

• Splicing then occurs to eliminate noncoding segments of the gene, known as introns, which don't contribute to the amino acid sequence.
• The coding parts of the gene, called exons, remain.
• Spliceosomes, along with specific proteins, remove the introns and splice together the exons, resulting in a shorter mRNA transcript.
• The intron sequences, constituting about 90% of a typical human gene, are not translated.

RNA Processing



Alternative Splicing

• During RNA processing, all the exons of a gene are brought together
• By using different combinations of the same exons, different proteins can be created.
• So, alternative splicing results in the ability of one gene to produce multiple different proteins.

In humans, genes may be spliced together in different ways.

Translation

• Synthesizing a protein from an mRNA sequence on a ribosome

Ribosomes

• consist of two subunits:
• a small subunit and a large subunit
• mRNA binds to the small subunit.
• The large subunit has three binding sites, **A (Amino acid), P (Polypeptide) and E (Exit)** sites

Translation Cont'd

• To correctly read a gene, a cell must translate the information encoded in the DNA into the language of proteins.
• The mRNA is "read" in three-nucleotide units called codons.
• Each codon corresponds to a particular amino acid.
• It is the tRNA molecules that bring amino acids to the ribosome to use in making proteins.

**Transfer RNA (tRNA)

• tRNA molecules each have a special three nucleotide RNA sequence called an anticodon.
• The anticodon is complementary to one of the 64 codons of the genetic code
• tRNA molecules also each bind an amino acid at one end.
• There are more than 20 different tRNA molecules, so some tRNAs bind to the same amino acids.

Translation Cont'd

• After an mRNA molecule attaches to the small ribosomal subunit, the larger ribosomal subunit joins, forming a full ribosome.

Translation (cont)

• During translation, the mRNA moves through the ribosome in sets of three nucleotides at a time.
• As this happens, a fresh tRNA carrying an amino acid to be added enters the ribosome at the A site.
• Translation proceeds until a stop codon marks the end of the protein synthesis process. At this point, the ribosome disassembles, and the newly synthesized protein is released into the cell.
• In eukaryotic cells, after translation, proteins undergo folding into secondary and tertiary structures and may undergo additional processing within the Golgi apparatus.

Genetic Code (need to understand for mRNA)

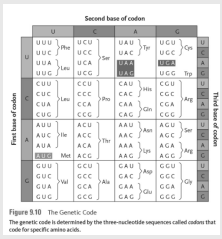


Figure 9.10 The Genetic Code
The genetic code is determined by the three-nucleotide sequences called codons that code for specific amino acids.

• Made of 3 bases (nucleotides)
• Every 3 bases on the mRNA is called a codon that codes for a particular amino acid in translation
• There are 64 possible codons
• Also called the triplet code
• **'Start'** refers to the first amino acid in a protein. (It is almost always a methionine with codon AUG).
• **'Stop'** refers to the signal that indicates that translation is over.
• Does not code for an amino acid.