Chapter 11-12 DNA Replication & Protein Synthesis

Questions you should be able to answer after this lecture.

1. WHAT IS DNA?
2. Where in cell cycle does DNA get replicated?
3. What is a mutation and why is mutation important?
4. What is transcription & translation?
5. Define introns and exons
6. What regulates gene expression?

Structure of DNA

DNA is comprised of subunits called nucleotides
each DNA nucleotide has three parts

1. a central dexoyribose sugar
2. a phosphate group
3. an organic base

Nucleotides differ with regards to their bases

- *large bases* (purines) with double-ring structure: either adenine (A) or guanine (G)
- *small bases* (pyrimidines) with single rings
- either cytosine (C) or thymine (T)

DNA always has = amounts of purines & pyrimidines

Chargaff's rule:
the amount of A = the amount of T
the amount of C = the amount of G

structure of DNA is a double helix

- two strands of DNA bind together by their bases
- because a purine of one strand binds to a pyrimidine on the other strand to form a base pair, the molecule keeps a constant thickness

How the DNA Molecule Copies Itself

- The two strands of DNA that form the double helix DNA molecule are complementary to each other
- each chain is essentially a mirror image of the other
- this makes it possible for DNA to copy itself in preparation for cell division

The process of DNA replication involves several enzymes

- At the replication fork, a primer must first be added to give a place for **DNA polymerase** to start from one template,
- DNA polymerase adds nucleotides in a continuous fashion; this new daughter strand is called the leading strand
- this second daughter strand is assembled in segments, each one beginning with a primer
- the segments will be joined together to form the lagging strand
- Before the newly formed DNA molecules wind back into the double helix shape, the primers must be removed and the DNA fragments sealed together
- **DNA ligase** joins the ends of the fragments of DNA to form continuous strands
- Because so much DNA is being replicated in the many cells of the body, there is a potential for errors to occur
- DNA repair involves comparing the daughter strand to the parent DNA template to check for mistakes
- the proofreading is not perfect because mutations are still possible, although rare

MUTATIONS

2 general ways to alter the genetic message encoded in DNA
mutation

- ❖ results from errors in replication
- ❖ can involve changes, additions, or deletions to nucleotides
- ❖ recombination causes change in the position of all or part of a gene

Mutations can alter the genetic message and affect protein synthesis
the effect of a mutation depends on the identity of the cell where it occurs

mutations in germ-line cells

- ❖ passed to future generations
- ❖ important for evolutionary change

mutations in somatic cells

- ❖ not passed to future generations but passed to all other somatic cells derived from it

Some mutations alter the sequence of DNA nucleotides

base substitution changes identity of base(s)
insertion adds a base(s)
deletion removes a base(s)

frame-shift mutation: insertion or deletion throws the reading frame of the gene message out of register,
extremely detrimental because the final protein intended by the message may be altered or not made

Some mutations affect how a genetic message is organized

Transposition: when individual genes move from one place in the genome to another
sometimes entire regions of chromosomes may change their relative location or undergo duplication

this is called chromosomal rearrangement

All evolutionary change begins with mutation

- ❖ mutation and recombination provide the raw materials for evolution
- ❖ Chemicals that causes mutation, called mutagens, appear to be linked to cancer
- ❖ for example, chemicals in cigarette smoke cause cancer

Transcription

- ❖ The information contained in DNA is stored in blocks called genes
- ❖ the genes code for proteins
- ❖ the proteins determine what a cell will be like
- ❖ The DNA stores this information safely in the nucleus where it never leaves
- ❖ instructions are copied from the DNA into messages comprised of RNA
- ❖ These messages are sent out into the cell to direct the assembly of proteins

DNA → RNA → protein
The path of information is often referred to as the central dogma

gene expression; takes place in two stages

1. Transcription: a messenger RNA (mRNA) is made from a gene within the DNA
2. Translation: mRNA is used to direct the production of a protein

Types of RNA

- ❖ RNA is the same as DNA except
- ❖ the sugars in RNA have an extra oxygen
- ❖ and T is replaced by another pyrimidine called uracil (U)

The cell uses three kinds of RNA

1. messenger RNA (mRNA),

2. ribosomal RNA (rRNA)

3. transfer RNA (tRNA)

Transcription is how is RNA made

- A protein called RNA polymerase produces the mRNA copy of DNA during transcription.

- 1st: it binds to one strand of the DNA at a site called the promoter & then moves down the DNA molecule and assembles a complementary copy of RNA

- transcription ends when the RNA polymerase reaches a certain nucleotide sequence that signals it stop

- To correctly read a gene, the mRNA is "read" in three-nucleotide units called codons

- each codon corresponds to a particular amino acid

Translation

- Translation occurs in ribosomes, which are the protein-making factories of the cell

- ribosome= proteins + ribosomal RNA (rRNA)

- ribosomes are comprised of two subunits
  - small subunit
  - large subunit

- mRNA binds to the small subunit

Translation continued……

- The large RNA subunit has three binding sites for transfer RNA (tRNA) located
- these binding sites are called the A, P, and E sites
- it is the tRNA molecules that bring amino acids to the ribosome to use in making proteins

The structure of a tRNA molecule is important to its function

- One end: holds an AA attachment
- Other end: holds a three-nucleotide sequence
- this three-nucleotide sequence is called the anticodon and is complementary to 1 of the 64 codons of the genetic code
- activating enzymes match the amino acids with their proper tRNAs
- Once the ribosomal unit is assembled
- the mRNA threads through the ribosome three nucleotides at a time
- a new tRNA holding an amino acid to be added enters the ribosome at the A site
- previous tRNA in the A site shifts to the P site
- At the P site peptide bonds from between the incoming amino acid and the growing chain of amino acids
- The now empty tRNA in the P site eventually shifts to the E site where it is released
- Translation continues until a "stop" codon is encountered that signals the end of the protein

- The ribosome then falls apart and the newly made protein is released into the cell

The coding portions of the DNA nucleotide sequence are interrupted by non-coding sections of DNA

- the coding portions: exons
- the non-coding portions: introns

- When a eukaryotic cell first transcribes a gene, it produces a primary RNA transcript of the entire gene
- the primary transcript is then processed in the nucleus
- enzyme-RNA complexes cut out the introns and join together the exons to form a shorter mRNA transcript
- the sequences of the introns (90% of typical human gene) are not translated

What is alternative splicing?

- In humans, genes may be spliced together in different ways
- by using different combinations of the same exons, different proteins can be created
- this is termed alternative splicing
- the 25,000 genes of the human genome appear to encode as many as 120,000 different mRNAs