Chapter 8 – From DNA to Proteins

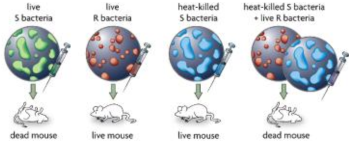
KEY CONCEPT – Section 1

DNA was identified as the genetic material through a series of experiments.

Chapter 8 – From DNA to Proteins

Griffith finds a ‘transforming principle.’

- Griffith experimented with the bacteria that cause pneumonia.
- He used two forms: the S form (deadly) and the R form (not deadly).
- A transforming material passed from dead S bacteria to live R bacteria, making them deadly.



Chapter 8 – From DNA to Proteins

Avery identified DNA as the transforming principle.

- Avery isolated and purified Griffith’s transforming principle.
- Avery performed three tests on the transforming principle.
  - Qualitative tests showed DNA was present.
  - Chemical tests showed the chemical makeup matched that of DNA.
  - Enzyme tests showed only DNA-degrading enzymes stopped transformation.

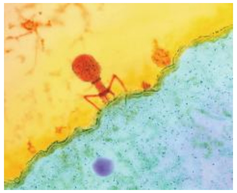
CHEMICAL ANALYSIS OF TRANSFORMING PRINCIPLE

	% Nitrogen (N)	% Phosphorus (P)	Ratio of N to P
Sample A	14.21	8.57	1.66
Sample B	15.93	9.09	1.75
Sample C	15.36	9.04	1.69
Sample D	13.40	8.45	1.58
Known value for DNA	15.32	9.05	1.69

Chapter 8 – From DNA to Proteins

Hershey and Chase confirm that DNA is the genetic material.

- Hershey and Chase studied viruses that infect bacteria, or bacteriophages.
  - They tagged viral DNA with radioactive phosphorus.
  - They tagged viral proteins with radioactive sulfur.



- Tagged DNA was found inside the bacteria; tagged proteins were not.

Chapter 8 – From DNA to Proteins

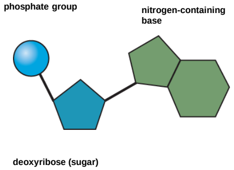
KEY CONCEPT – Section 2

DNA structure is the same in all organisms.

Chapter 8 – From DNA to Proteins

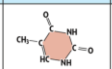
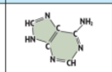
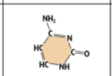
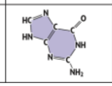
DNA is composed of four types of nucleotides.

- DNA is made up of a long chain of nucleotides.
- Each nucleotide has three parts.
  - a phosphate group
  - a deoxyribose sugar
  - a nitrogen-containing base



Chapter 8 – From DNA to Proteins

- The nitrogen containing bases are the only difference in the four nucleotides.

PYRIMIDINES = SINGLE RING			PURINES = DOUBLE RING		
Name of Base	Structural Formula	Model	Name of Base	Structural Formula	Model
thymine			adenine		
cytosine			guanine		

Chapter 8 – From DNA to Proteins

Watson and Crick determined the three-dimensional structure of DNA by building models.

- They realized that DNA is a double helix that is made up of a sugar-phosphate backbone on the outside with bases on the inside.

Chapter 8 – From DNA to Proteins

- Watson and Crick's discovery built on the work of Rosalind Franklin and Erwin Chargaff.
  - Franklin's x-ray images suggested that DNA was a double helix of even width.
  - Chargaff's rules stated that A=T and C=G.

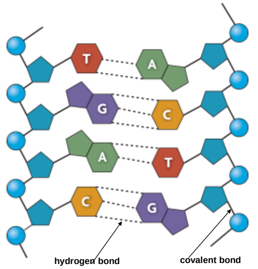
Chapter 8 – From DNA to Proteins

Nucleotides always pair in the same way.

- The base-pairing rules show how nucleotides always pair up in DNA.
  - A pairs with T
  - C pairs with G
- Because a pyrimidine (single ring) pairs with a purine (double ring), the helix has a uniform width.

Chapter 8 – From DNA to Proteins

- The backbone is connected by covalent bonds.
- The bases are connected by hydrogen bonds.



Chapter 8 – From DNA to Proteins

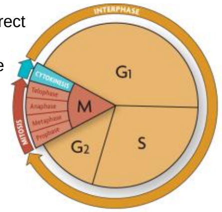
KEY CONCEPT – Section 3

DNA replication copies the genetic information of a cell.

Chapter 8 – From DNA to Proteins

Replication copies the genetic information.

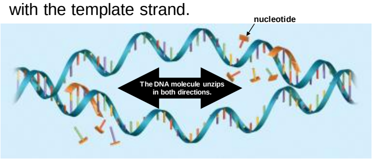
- A single strand of DNA serves as a template for a new strand.
- The rules of base pairing direct replication.
- DNA is replicated during the S (synthesis) stage of the cell cycle.
- Each body cell gets a complete set of identical DNA.



Chapter 8 – From DNA to Proteins

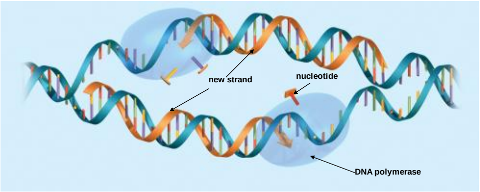
Proteins carry out the process of replication.

- DNA serves only as a template.
- Enzymes and other proteins do the actual work of replication.
  - Enzymes unzip the double helix.
  - Free-floating nucleotides form hydrogen bonds with the template strand.



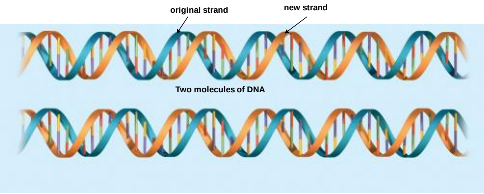
Chapter 8 – From DNA to Proteins

- DNA polymerase enzymes bond the nucleotides together to form the double helix.
- Polymerase enzymes form covalent bonds between nucleotides in the new strand.



Chapter 8 – From DNA to Proteins

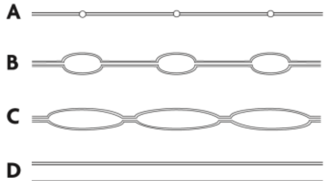
- Two new molecules of DNA are formed, each with an original strand and a newly formed strand.
- DNA replication is semiconservative.



Chapter 8 – From DNA to Proteins

Replication is fast and accurate.

- DNA replication starts at many points in eukaryotic chromosomes.



There are many origins of replication in eukaryotic chromosomes.

- DNA polymerases can find and correct errors.

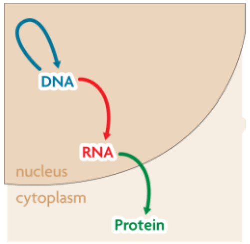
Chapter 8 – From DNA to Proteins

KEY CONCEPT – Section 4

Transcription converts a gene into a single-stranded RNA molecule.

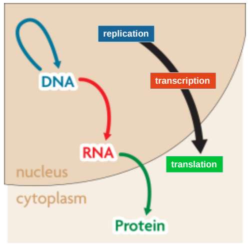
RNA carries DNA's instructions.

- The central dogma states that information flows in one direction from DNA to RNA to proteins.



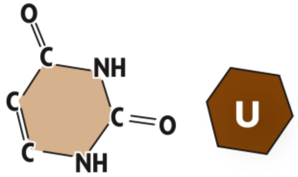
Chapter 8 – From DNA to Proteins

- The central dogma includes three processes.
  - Replication
  - Transcription
  - Translation
- RNA is a link between DNA and proteins.



Chapter 8 – From DNA to Proteins

- RNA differs from DNA in three major ways.
  - RNA has a ribose sugar.
  - RNA has uracil instead of thymine.
  - RNA is a single-stranded structure.



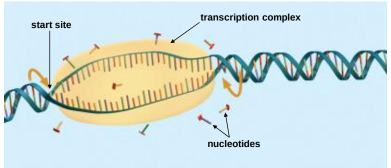
Chapter 8 – From DNA to Proteins

Transcription makes three types of RNA.

- Transcription copies DNA to make a strand of RNA.

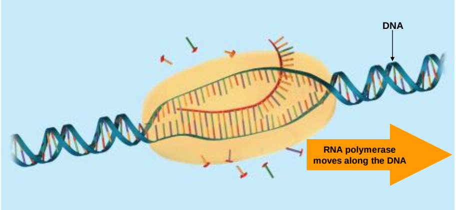
Chapter 8 – From DNA to Proteins

- Transcription is catalyzed by RNA polymerase.
  - RNA polymerase and other proteins form a transcription complex.
  - The transcription complex recognizes the start of a gene and unwinds a segment of it.



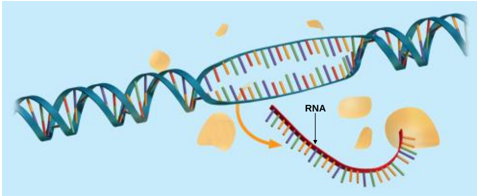
Chapter 8 – From DNA to Proteins

- Nucleotides pair with one strand of the DNA.
- RNA polymerase bonds the nucleotides together.
- The DNA helix winds again as the gene is transcribed.



Chapter 8 – From DNA to Proteins

- The RNA strand detaches from the DNA once the gene is transcribed.



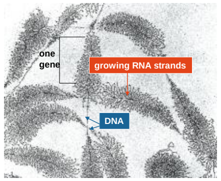
Chapter 8 – From DNA to Proteins

- Transcription makes three types of RNA.
  - Messenger RNA (mRNA) carries the message that will be translated to form a protein.
  - Ribosomal RNA (rRNA) forms part of ribosomes where proteins are made.
  - Transfer RNA (tRNA) brings amino acids from the cytoplasm to a ribosome.

Chapter 8 – From DNA to Proteins

The transcription process is similar to replication.

- Transcription and replication both involve complex enzymes and complementary base pairing.
- The two processes have different end results.
  - Replication copies all the DNA; transcription copies a gene.
  - Replication makes one copy; transcription can make many copies.



Chapter 8 – From DNA to Proteins

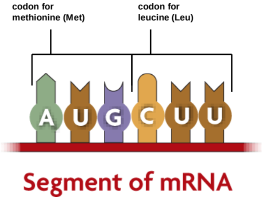
KEY CONCEPT – Section 5

Translation converts an mRNA message into a polypeptide, or protein.

Chapter 8 – From DNA to Proteins

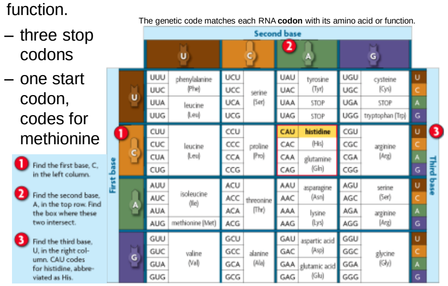
Amino acids are coded by mRNA base sequences.

- Translation converts mRNA messages into polypeptides.
- A codon is a sequence of three nucleotides that codes for an amino acid.



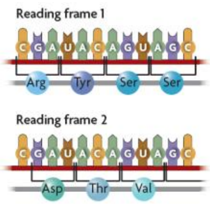
Chapter 8 – From DNA to Proteins

- The genetic code matches each codon to its amino acid or function.
  - three stop codons
  - one start codon, codes for methionine



Chapter 8 – From DNA to Proteins

- A change in the order in which codons are read changes the resulting protein.

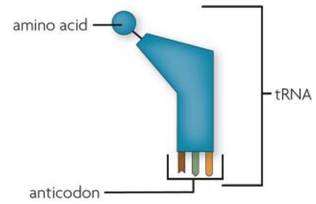


- Regardless of the organism, codons code for the same amino acid.

Chapter 8 – From DNA to Proteins

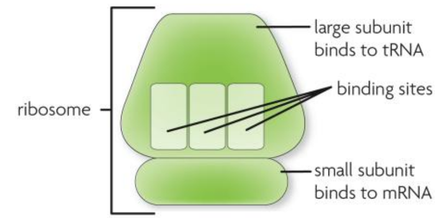
Amino acids are linked to become a protein.

- An anticodon is a set of three nucleotides that is complementary to an mRNA codon.
- An anticodon is carried by a tRNA.



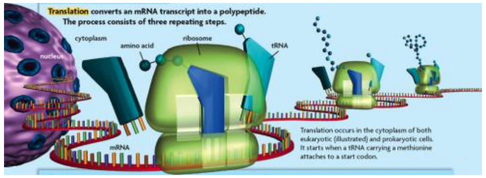
Chapter 8 – From DNA to Proteins

- Ribosomes consist of two subunits.
  - The large subunit has three binding sites for tRNA.
  - The small subunit binds to mRNA.



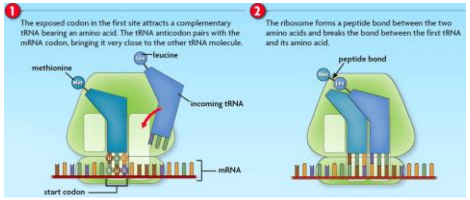
Chapter 8 – From DNA to Proteins

- For translation to begin, tRNA binds to a start codon and signals the ribosome to assemble.
  - A complementary tRNA molecule binds to the exposed codon, bringing its amino acid close to the first amino acid.



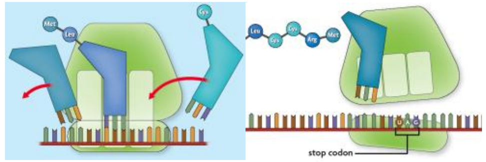
Chapter 8 – From DNA to Proteins

- The ribosome helps form a polypeptide bond between the amino acids.
- The ribosome pulls the mRNA strand the length of one codon.



Chapter 8 – From DNA to Proteins

- The now empty tRNA molecule exits the ribosome.
- A complementary tRNA molecule binds to the next exposed codon.
- Once the stop codon is reached, the ribosome releases the protein and disassembles.



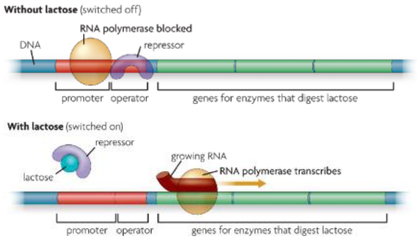
KEY CONCEPT – Section 6

Gene expression is carefully regulated in both prokaryotic and eukaryotic cells.

Prokaryotic cells turn genes on and off by controlling transcription.

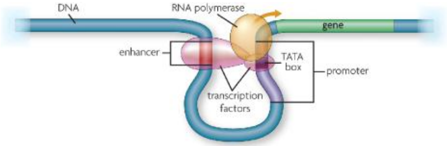
- A promotor is a DNA segment that allows a gene to be transcribed.
- An operator is a part of DNA that turns a gene “on” or ”off.”
- An operon includes a promoter, an operator, and one or more structural genes that code for all the proteins needed to do a job.
  - Operons are most common in prokaryotes.
  - The *lac* operon was one of the first examples of gene regulation to be discovered.
  - The *lac* operon has three genes that code for enzymes that break down lactose.

- The *lac* operon acts like a switch.
  - The *lac* operon is “off” when lactose is not present.
  - The *lac* operon is “on” when lactose is present.

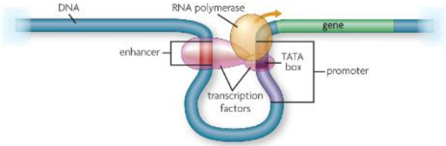


Eukaryotes regulate gene expression at many points.

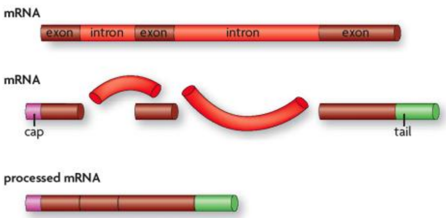
- Different sets of genes are expressed in different types of cells.
- Transcription is controlled by regulatory DNA sequences and protein transcription factors.



- Transcription is controlled by regulatory DNA sequences and protein transcription factors.
  - Most eukaryotes have a TATA box promoter.
  - Enhancers and silencers speed up or slow down the rate of transcription.
  - Each gene has a unique combination of regulatory sequences.



- RNA processing is also an important part of gene regulation in eukaryotes.
- mRNA processing includes three major steps.



Chapter 8 – From DNA to Proteins

- mRNA processing includes three major steps.
  - Introns are removed and exons are spliced together.
  - A cap is added.
  - A tail is added.

Chapter 8 – From DNA to Proteins

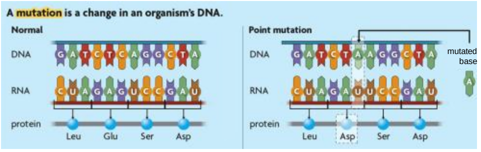
KEY CONCEPT – Section 7

Mutations are changes in DNA that may or may not affect phenotype.

Chapter 8 – From DNA to Proteins

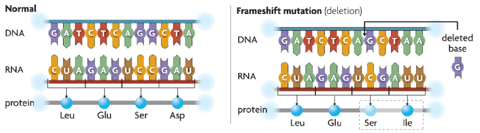
Some mutations affect a single gene, while others affect an entire chromosome.

- A mutation is a change in an organism's DNA.
- Many kinds of mutations can occur, especially during replication.
- A point mutation substitutes one nucleotide for another.



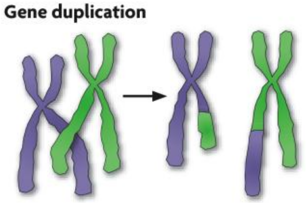
Chapter 8 – From DNA to Proteins

- Many kinds of mutations can occur, especially during replication.
  - A frameshift mutation inserts or deletes a nucleotide in the DNA sequence.



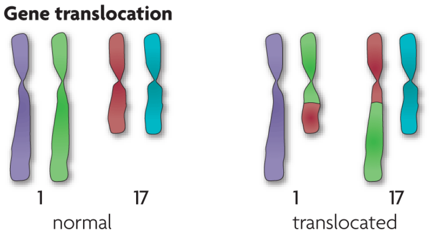
Chapter 8 – From DNA to Proteins

- Chromosomal mutations affect many genes.
- Chromosomal mutations may occur during crossing over
  - Chromosomal mutations affect many genes.
  - Gene duplication results from unequal crossing over.



Chapter 8 – From DNA to Proteins

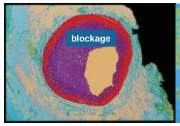
- Translocation results from the exchange of DNA segments between nonhomologous chromosomes.

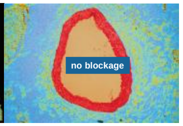


Chapter 8 – From DNA to Proteins

Mutations may or may not affect phenotype.

- Chromosomal mutations tend to have a big effect.
- Some gene mutations change phenotype.
  - A mutation may cause a premature stop codon.
  - A mutation may change protein shape or the active site.
  - A mutation may change gene regulation.





Chapter 8 – From DNA to Proteins

- Some gene mutations do not affect phenotype.
  - A mutation may be silent.
  - A mutation may occur in a noncoding region.
  - A mutation may not affect protein folding or the active site.

Chapter 8 – From DNA to Proteins

- Mutations in body cells do not affect offspring.
- Mutations in sex cells can be harmful or beneficial to offspring.
- Natural selection often removes mutant alleles from a population when they are less adaptive.

Chapter 8 – From DNA to Proteins

Mutations can be caused by several factors.

- Replication errors can cause mutations.
- Mutagens, such as UV ray and chemicals, can cause mutations.
- Some cancer drugs use mutagenic properties to kill cancer cells.