8.1 Identifying DNA as the Genetic Material **DNA was identified as the genetic material through a series of experiments.**

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.

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.

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.

8.2 Structure of DNA **DNA structure is the same in all organisms.**

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

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

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.

* 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.

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.

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

8.3 DNA Replication  
DNA replication copies the genetic information of a cell.

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.

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.
  + DNA polymerase enzymes bond the nucleotides together to form the double helix.
  + Polymerase enzymes form covalent bonds between nucleotides in the new strand.
* Two new molecules of DNA are formed, each with an original strand and a newly formed strand.
* DNA replication is semiconservative.

Replication is fast and accurate.

* DNA replication starts at many points in eukaryotic chromosomes.
* DNA polymerases can find and correct errors.

8.4 Transcription

**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.
* The central dogma includes three processes.
  + Replication
  + Transcription
  + Translation
* RNA is a link between DNA and 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.
* Transcription makes three types of RNA.
  + Transcription copies DNA to make a strand of RNA.
* 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.
  + Nucleotides pair with one strand of the DNA.
  + RNA polymerase bonds the nucleotides together.
  + The DNA helix winds again as the gene is transcribed.
  + The RNA strand detaches from the DNA once the gene   
     is transcribed.
* 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.

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.

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

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.

The genetic code matches each codon to its amino acid or function.

* + three stop codons
  + one start codon, codes for methionine
* 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.

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.

Ribosomes consist of two subunits.

* + The large subunit has three binding sites for tRNA.
  + The small subunit binds to mRNA.

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

8.6 Gene Expression & Regulation **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 1st examples of gene regulation

- The *lac* operon has 3 genes coding 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.
* mRNA processing includes three major steps.
  + Introns are removed and exons are spliced together.
  + A cap is added.
  + A tail is added.

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

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 frameshift mutation inserts or deletes a nucleotide in the DNA sequence.
* A point mutation substitutes one nucleotide for another.
* Chromosomal mutations affect many genes.
* Chromosomal mutations may occur during crossing over
  + Chromosomal mutations affect many genes.
  + Gene duplication results from unequal crossing over.
* Translocation results from the exchange of DNA segments between nonhomologous chromosomes.

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.
* 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.
* 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.

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.