Chapter 11
DNA Structure and Function
Early and Puzzling Clues

- In 1869, Johann Miescher was studying the composition of the nucleus.
- He found an acidic substance that contains nitrogen and phosphorous.
- Later it would be called as deoxy ribonucleic acid (DNA).
Griffith’s Experiments

• In 1928
• He was attempting to develop a pneumonia vaccine
• Isolated two strains of *Streptococcus pneumoniae*
• 1 Rough Strain - Harmless
• 2 Smooth Strain - Pathogenic
Griffith’s Experiments

Mice injected with live cells of harmless strain R do not die. Live R cells in their blood.

Mice injected with live cells of killer strain S die. Live S cells in their blood.

Mice injected with heat-killed S cells do not die. No live S cells in their blood.

Mice injected with live R cells plus heat-killed S cells die. Live S cells in their blood.
Griffith’s Experiments

- In the fourth experiment
- Heat killed the S cells, but did not destroy their hereditary material.
- Hereditary material was transferred from the dead S cells to living R cells
- Thus the harmless R cells had been transformed
Bacteriophages

- A type of viruses that infect bacteria
- They are made of an outer protein coat that encloses the genetic material (which can be an RNA or DNA)
- They inject their genetic material into the bacteria
Hershey and Chase’s Experiments

- Experiment – 1
- Bacteriophages are labeled with radioisotope of sulfur ($^{35}$s)
- Sulfur is present in protein
- The bacteria were infected with sulfur labeled bacteriophages
- Analysis revealed the presence of radioactive protein in the viral coats, not in the bacterial cells
Virus DNA labeled with $^{35}$S

DNA being injected into bacterium

3$^5$S remains outside cells

Virus DNA labeled with $^{32}$P

Labeled DNA being injected into bacterium

3$^2$P remains inside cells
Key Concepts:

DISCOVERY OF DNA’S FUNCTION

- In all living cells, DNA molecules store information that governs heritable traits
Discovery of DNA Structure

- DNA consists of two strands of nucleotides, coiled into a double helix

- Each nucleotide has
  - A five-carbon sugar (deoxyribose)
  - A phosphate group
  - A nitrogen-containing base (adenine, thymine, guanine, or cytosine)
Discovery of DNA Structure
DNA’s Building Blocks

Chargaff’s Rule

- Amount of thymine and adenine in DNA are the same, as are the amounts of guanine and cytosine
- Amount of adenine and guanine differs among species
- A=T and G=C
Base Pairing

- Bases of two DNA strands pair in only one way
  - Adenine with thymine (A-T)
  - Guanine with cytosine (G-C)

- The DNA sequence (order of bases) varies among species and individuals
DNA Nucleotides

- **Adenine (A)**: Base with a double-ring structure.
  - Sugar: Deoxyribose.

- **Guanine (G)**: Base with a double-ring structure.

- **Thymine (T)**: Base with a single-ring structure.

- **Cytosine (C)**: Base with a single-ring structure.

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A DNA molecule consists of two chains of nucleotides, hydrogen-bonded together along their length and coiled into a double helix.

Four kinds of nucleotides make up the chains: adenine, thymine, guanine, and cytosine.
Key Concepts:

THE DNA DOUBLE HELIX (cont.)

• The order in which one kind of nucleotide base follows the next along a DNA strand encodes heritable information

• The order in some regions of DNA is unique for each species
Watson, Crick, and Franklin

- Rosalind Franklin’s research produced x-ray diffraction images of DNA
- Helped Watson and Crick build their DNA model, for which they received the Nobel Prize
In all respects shown here, the Watson–Crick model for DNA structure is consistent with the known biochemical and x-ray diffraction data.

The pattern of base pairing (A with T, and G with C) is consistent with the known composition of DNA (A = T, and G = C).
Patterns of Base Pairing

Patterns of base pairing include:

- **GGCCCCCTTTC**
- **CCGGGGGAAG**
- One base pair

or

- **GCACCAATA**
- **CGTGTTTAT**

or

- **AAAAAAAAAA**
- **TTTTTTTTTT**
DNA Replication and Repair

- A cell replicates its DNA before dividing
  - Enzymes unwind the double helix
  - DNA polymerases assemble complementary DNA strands on templates from free nucleotides
  - DNA ligase seals gaps in new DNA strands

- Two double-stranded DNA molecules result
  - One strand of each is new
Semiconservative DNA Replication
Part of a parent DNA molecule, with two complementary strands of base-paired nucleotides.

Replication starts. The strands are unwound at many sites along the molecule’s length.

Each of the two parent strands guides the assembly of new DNA strands from free nucleotides, according to base-pairing rules.

Any gaps between bases of the “new” DNA are joined to form a continuous strand. The base sequence of each half-old, half-new DNA molecule is identical to that of the parent.
New DNA is assembled continuously on only one of the two parent template strands. It is assembled on the other parent template strand in short fragments. DNA ligase seals the gaps between the fragments.

Why discontinuous assembly? DNA synthesis occurs only in the 5’ to 3’ direction. Free nucleotides can be added only to the —OH group at the 3’ end of a growing strand.
Replication Errors

- DNA repair mechanisms fix DNA damaged by chemicals or radiation
- Proofreading by DNA polymerases corrects most base-pairing errors
- Uncorrected errors are mutations
Key Concepts:

**HOW CELLS DUPLICATE THEIR DNA**

- *Before a cell divides, enzymes and other proteins copy its DNA*

- *Newly forming DNA strands are monitored for errors, most of which are corrected*

- *Uncorrected errors are mutations*
Cloning

- **Clones**
  - Genetically identical individuals
  - Produced by artificial twinning, nuclear transfers

- To clone an adult animal
  - Cell’s DNA must be reprogrammed to function like an embryonic cell and direct development
Nuclear Transfer

**a** A microneedle is about to penetrate an unfertilized sheep egg.

**b** The microneedle has now removed the sheep egg’s nucleus.

**c** A nucleus from a donor cell is about to be inserted into the enucleated egg.

**d** An electric current will stimulate the egg to enter mitotic cell division. After a few rounds of divisions, the ball of cells will be implanted in the womb of a female sheep (ewe). *Left*, Dolly, the first sheep cloned from adult DNA.
Key Concepts: DNA AND THE CLONING CONTROVERSIES

- Knowledge about the structure and function of DNA is the basis of several methods of cloning