Chapter 9

DNA: The Molecule of Heredity

What is DNA?

Answer: Molecule that carries the blueprint of life

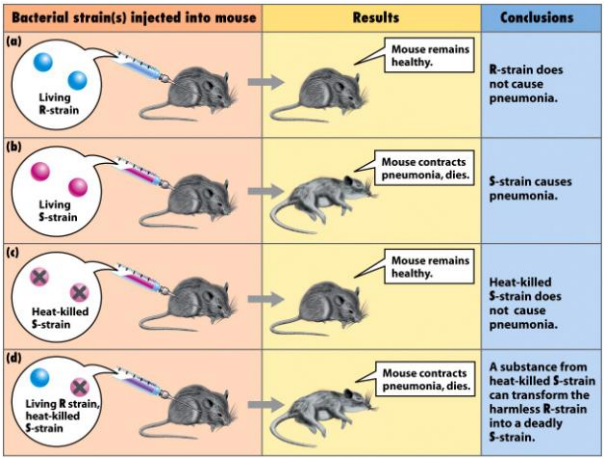
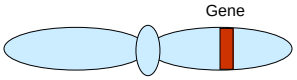
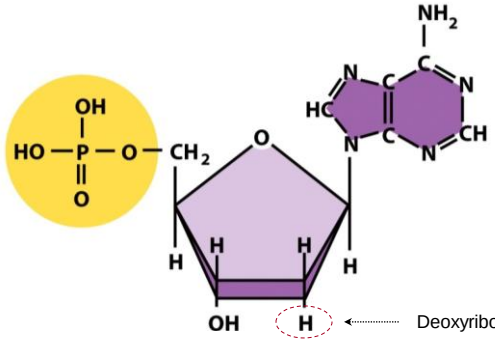


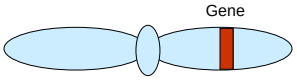
Figure 9.1 – Audesirk[2] & Byers



General Features of DNA:

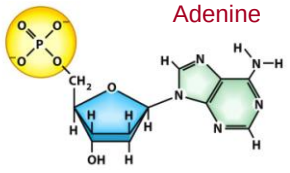
- DNA is packages in chromosomes (DNA + Proteins)
  - Gene = Functional segment of DNA located at a particular place on a chromosome
- DNA is a nucleic acid, composed of individual nucleotides (review…)

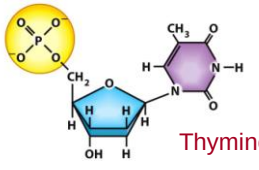


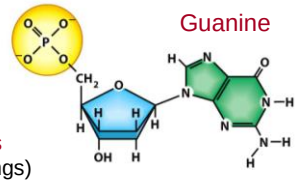


General Features of DNA:

- DNA is packages in chromosomes (DNA + Proteins)
  - Gene = Functional segment of DNA located at a particular place on a chromosome
- DNA is a nucleic acid, composed of individual nucleotides (review…)
- 4 types of nucleotides (nitrogen base differences):







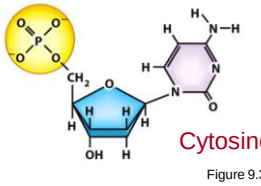


Figure 9.3 – Audesirk[2] & Byers

How are the Nucleic Acids arranged to form DNA?

Historical Background:

1) Chargaff (1940s):
   - DNA contains equal amounts of adenine and thymine
   - DNA contains equal amounts of cytosine and guanine

   } "Chargaff's rule"

2) Franklin and Wilkens (early 1950s):
   - Used X-ray diffraction
     - DNA is a helical molecule (corkscrew)
     - DNA has a uniform diameter (2 nm)
     - DNA consists of repeating sub-units

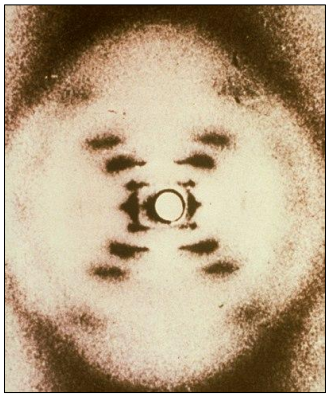


Figure 9.4 – Audesirk[2] & Byers

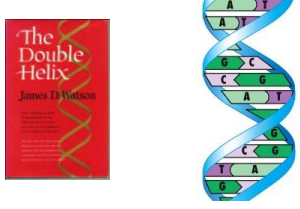
Chapter 9: DNA – The Molecule of Heredity

How are the Nucleic Acids arranged to form DNA?

Historical Background:

3) Watson & Crick (1953):
   - DNA is two separate strands of linked nucleotides
     - Phosphate groups bonded to sugar groups (backbone)
     - Antiparallel (strands opposite one another)
   - DNA strands held together by hydrogen bonding
     - Adenine → Thymine
     - Guanine → Cytosine

     } Complementary base pairing
   - Strands twisted to form double helix



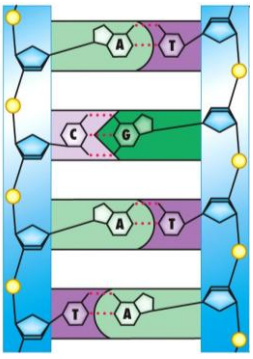
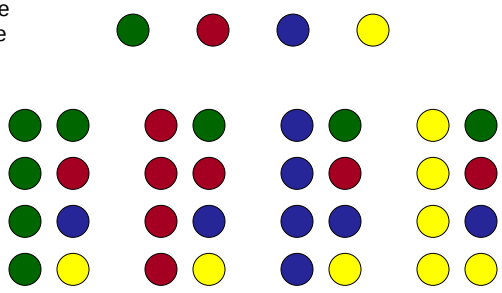


Figure 9.5 – Audesirk[2] & Byers

How does DNA encode information?

Answer: The sequential order of nucleotides

How many unique groups of two are possible?



16 (4 x 4)

10 “nucleotides” = > 1,000,000 possible sequences

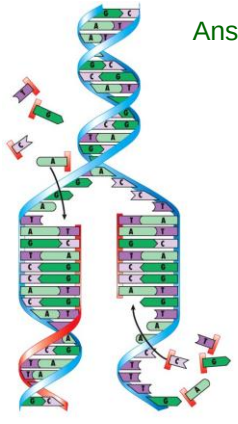
- Organisms have <u>millions</u> (bacteria) to <u>billions</u> (plants / animals) of nucleotides composing their DNA…

Figure 9.6 / 9.7 – Audesirk[2] & Byers

The copying of DNA is a critical event in a cell’s life

- A single parental cell produces two daughter cells during reproduction
- Each daughter cell must receive an <u>exact</u> copy of DNA

How does DNA make an exact copy of itself?

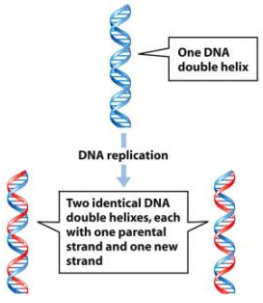


Answer: The process of DNA replication

A) Parental strands unwind and separate

B) Daughter strands are formed using the parental strands as templates

C) Parental and new daughter strands wrap together to form new double helix



Semi-conservative replication

Figure E9.7 – Audesirk² & Byers

How does DNA make an exact copy of itself?

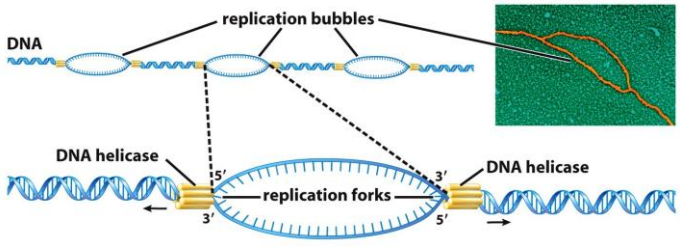
Answer: The process of DNA replication

DNA Replication – A Closer Look...

Step 1: DNA strand separation

- DNA Helicase (enzyme) breaks hydrogen bonds holding bases together

"unzips" DNA



- Requires energy
- Multiple DNA helicases work on a single strand (form replication bubbles)

Chapter 9: DNA – The Molecule of Heredity

Figure E9.7 – Audesirk² & Byers

How does DNA make an exact copy of itself?

Answer: The process of DNA replication

DNA Replication – A Closer Look...

Step 2: DNA synthesis

- DNA Polymerase (enzyme) joins nucleotide sub-units to form new strand
  - Forms complementary base pairs to parental strand

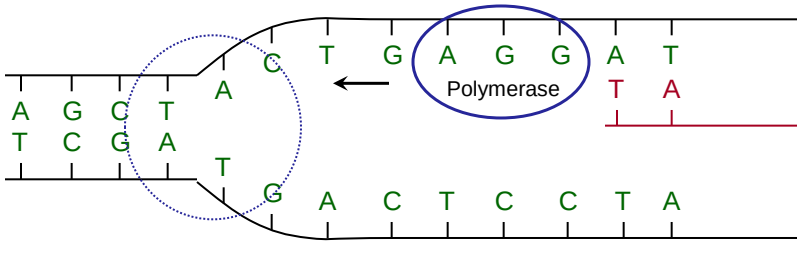


Figure E9.7 – Audesirk² & Byers

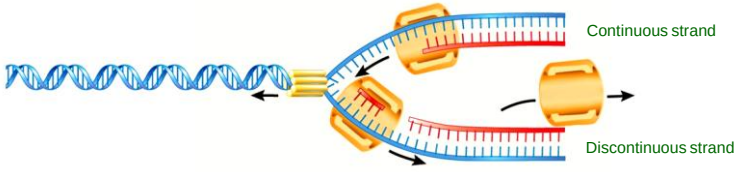
How does DNA make an exact copy of itself?

Answer: The process of DNA replication

DNA Replication – A Closer Look...

Step 2: DNA synthesis

- DNA Polymerase (enzyme) joins nucleotide sub-units to form new strand
  - Forms complementary base pairs to parental strand
  - DNA Polymerase can only move in one direction
    - One strand synthesized as a continuous molecule
    - One strand synthesized in small pieces



Chapter 9: DNA – The Molecule of Heredity

Figure E9.7 – Audesirk² & Byers

How does DNA make an exact copy of itself?

Answer: The process of DNA replication

DNA Replication – A Closer Look...

Step 3: Joining of DNA fragments

- DNA Ligase joins small segments into single strand (e.g., discontinuous strand)

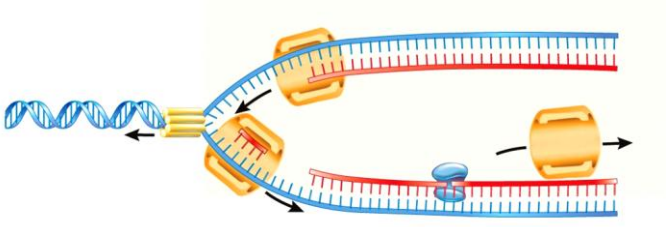


Figure E9.7 – Audesirk[2] & Byers

How does DNA make an exact copy of itself?

Answer: The process of DNA replication

Mistakes Happen!

DNA replication is a rapid process (~ 700 nucleotides / sec.)

A) DNA polymerase mismatches ~ 1 bp / 10,000 bps
   - Proof-reading enzymes correct mistakes
   - Overall mistake rate = 1 bp / 1,000,000,000 bps

B) Environmental hazards damage DNA
   - Body temperature (98.6°F) = 10,000 bp lost / day
   - Ultraviolet light

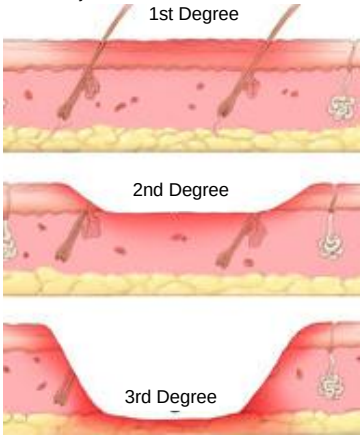
Sun Burns:

UV light from sun damages DNA

If damage is great enough,
cell will commit cellular suicide

If damage in region of DNA
controlling replication, cancer may result

Asymmetry
Border (irregular)
Color (irregular)
Diameter (large)



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B) Environmental hazards damage DNA
   - Body temperature (98.6°F) = 10,000 bp lost / day
   - Ultraviolet light
   - X-rays

➢ Repair enzymes fix damaged DNA