

Chapter 16—The molecular Basis of Inheritance

Read Pages 293-304

Work problems 3, 4, 5, 8

You should know:

The structure of the double helix (what is a nucleotide, what is the sugar-phosphate backbone, what does antiparallel mean, what are the four bases found in nucleotides...)

What is complementary base pairing and which bases pair with each other

How does complimentary base pairing function during replication

What is the direction of synthesis of a new DNA strand?

What are the leading and lagging strands during synthesis

What enzymes are involved in synthesis and what do they do?

What is the molecular structure of the genetic material and how is it transmitted from one generation to the next?

Early in the 1900s geneticists knew that:

- “Genes” (=the hereditary information) were located on chromosomes
- Chromosome are composed of both DNA and protein

Until the 1950s protein was thought to be the genetic material

Experiments summarized in figs. 16.2 and 16.4 demonstrated that DNA is the genetic material

How can such a simple molecule encode complex information?

THE STRUCTURE OF DNA

Discovered by James Watson, Francis Crick, and Rosalind Franklin in the 1950s (summarized on pages 296-297)

Fig. 16.7a

- DNA exists as a double helix, two strands of DNA held together by hydrogen bonds.
- The double stranded DNA is then twisted around in a helix.
- Each strand is a polymer of **nucleotides**
- Single strands can be called nucleic acids
- Deoxyribonucleic acid

Fig. 5.26

One strand of DNA = a polymer of nucleotides

A nucleotide consists of

- A nitrogen containing base
- A sugar (deoxyribose)
- A phosphate

The phosphate of one nucleotide is covalently bonded to the sugar of the next

Forming a backbone consisting of the sugar-phosphate linkages

The nitrogenous bases stick off to the side

Fig 16.5

There are four types of nucleotides each with a different nitrogenous base

Thymine and Cytosine have one ring. Adenine and Guanine have two rings

A DNA strand (a polymer of nucleotides) has **polarity**

Phosphate at the 5' end of the backbone

Sugar at the 3' end of the backbone

5' and 3' refer to the orientation of the sugar that contributes to the backbone

Fig. 16.7

- The two DNA strands of the double helix are antiparallel. They have opposite polarity
- The sugar backbones of each strand face out and the nitrogenous bases face inward
- The two strands of the double helix are held together by hydrogen bonds between bases

Fig 16.8 The nitrogenous bases of the double helix are always paired in specific combinations.

A purine always pairs with a pyrimidine

Adenine always pairs with Thymine (2 H bonds)

Guanine always pairs with Cytosine (3 H bonds)

Summary

- Two strands of nucleic acid
- Each is a polymer of nucleotides
- Sugar-phosphate backbone
- polarity
- Strands are antiparallel
- Nitrogenous bases inward
- Hydrogen bonding between A and T, C and G, hold strands together

DNA REPLICATION

“It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material” JD Watson and FH Crick. 1953.

Molecular structure of nucleic acids: a structure for deoxynucleic acids. Nature 171:738.

FIG. 16.7

The sequence of nucleotides on one strand determines the sequence of nucleotides on the other
The strands are complementary: each strand has all of the information necessary to reconstruct the other

Fig. 16.9 A model for DNA replication

A. The parent molecule has two complementary strands of DNA. Each base is paired by hydrogen bonding with its specific partner, A with T and G with C.

B. The first step in replication is separation of the two DNA strands.

C. Each parental strand now serves as a template that determines the order of nucleotides along a new, complementary strand.

D. The nucleotides are connected to form the sugar-phosphate backbones of the new strands. Each “daughter” DNA molecule consists of one parental strand of one new strand.

Base pairing = the process of matching A-T and G-G
Each DNA molecule has 5 base pairs

Fig. 5,27 A different view of replication.

Astonishing numbers

Each human cell has 46 chromosomes

Each chromosome includes one long double helix (plus some proteins)

A total of 6 billion base pairs!

All of this is replicated in only a few hours (during S phase) with only about one error per 10 billion base pairs

Fig. 16.12 Initiation of DNA replication

- Replication begins at origin of replication
- Requires enzymes to separate the two strands
- Separated strands form a bubble
- Multiple origins of replication per chromosome
- Both parental (template) strands are copied.
- Replication via base pairing occurs at the replication fork
- Strands are copied in both directions
- Bubbles meet and fuse
- Result is two new DNA molecules
- Each consists of one parental strand and one new (daughter) strand

Fig. 5.26 Strand Elongation--building blocks are nucleoside triphosphates

Fig. 16.13 Strand Elongation

- Building blocks of new DNA strand are nucleoside triphosphates
- High energy phosphates provide the energy to drive polymerization of the nucleotides
- New nucleotides are being added to the 3' end of the new strand
- Incoming nucleoside triphosphate is selected by base pairing
- Phosphate at 5' end of the nucleotide triphosphate joins to the sugar at the 3' end of the new strand
- DNA polymerase is the catalyst

BIG PROBLEM A new DNA strand can only elongate 5' → 3'

But both strands need to be copied in the same direction

Inset from fig. 16.16 Solution to the problem

One new strand is synthesized continuously in the 5' → 3' direction = leading strand

The other strand is synthesized in bits and then stitched together = lagging strand

See attached figure for the rest of this lecture.