BIOL1090-01 Lecture 13: February 24, 2014

DNA and chromosome structure

Snustad & Simmons, 6th ed.
Chapter 9, pp.197 - 214

(5th ed. pp.215 - 239)

(not the last section "Repeated DNA sequences")

Genomes are not deterministic: interactions of genomes with environment.

"genetic determinism" - environment has little effect
Genetics is fundamental to life.

The four nucleotides of DNA

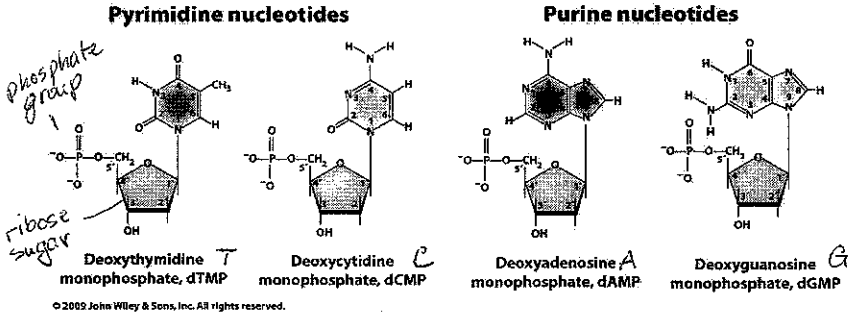


Fig. 9.6

At the heart of genes and genetics: DNA

Deoxyribonucleic acid (DNA) is a polymer

Each subunit is a nucleotide comprised of:

- a phosphate group
- a five carbon sugar (2-deoxyribose)
- one of four cyclic nitrogenous bases
  A, C, G, T

Population variation is the substrate on which natural selection acts.

The purine and pyrimidine nucleotides in polynucleotide chains are connected by phosphodiester bonds

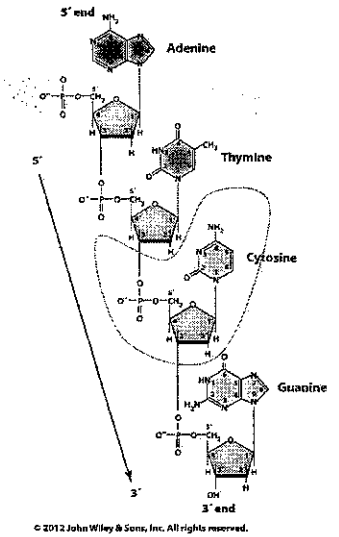


Fig. 9.7

DNA is double-stranded
and the strands are antiparallel

The double helix is right-handed
clockwise twist

The strands are held together
by hydrogen bonds between bases
on opposing strands and by
hydrophobic interactions
between adjacent stacked bases
- the bonds provide stability

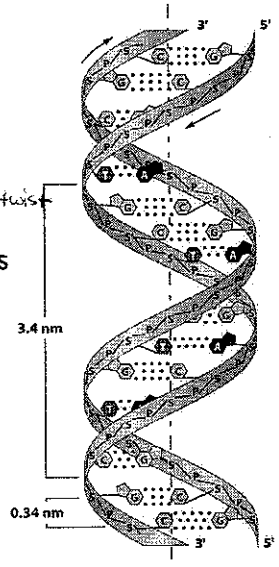


Fig. 9.10

DNA strands are polar:

Each strand of DNA
has chemical polarity:

5' end (five prime end)
has a free phosphate
group

3' end (three prime end)
has a free hydroxyl
group

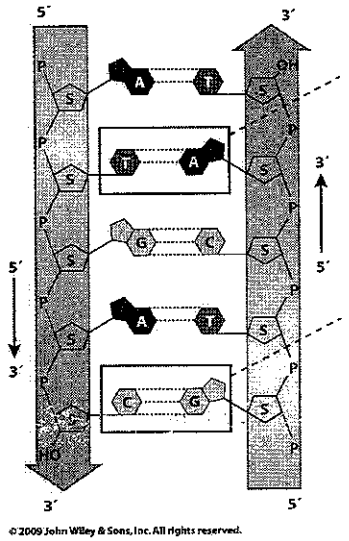


Fig. 9.11

Opposing strands
are said to be
complementary

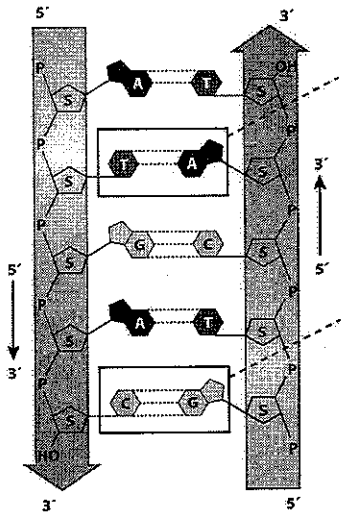
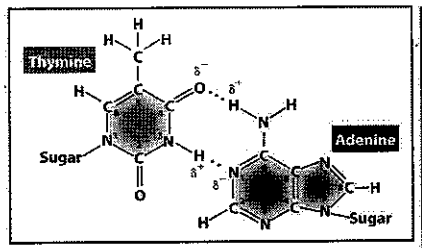
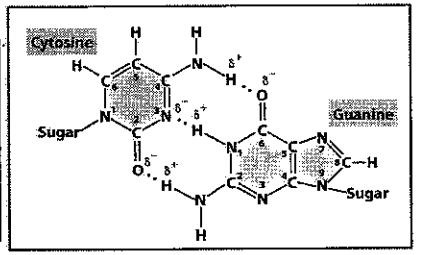


Fig. 9.11

Base pairing is specific and is mediated by hydrogen bonds



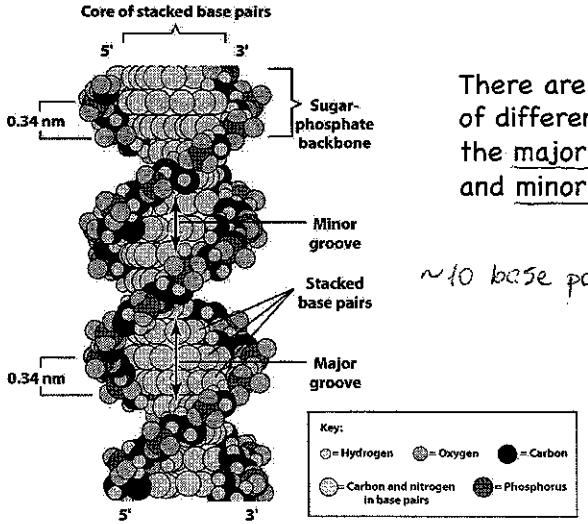


- slightly more energy involved
b/c three hydrogen bonds

- the higher the proportion of C-G base pairs, the more energy in the DNA strand (harder to break apart)

Fig. 9.11

The most common form of DNA is called B-DNA



There are two grooves of different width: the major groove and minor groove

~10 base pair per 360° turn

Fig. 9.12

The DNA in living cells is supercoiled

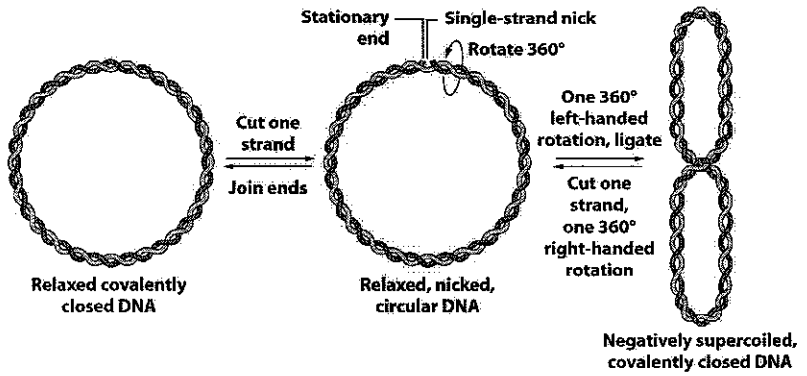


Fig. 9.14

The functional prokaryotic chromosome is highly compact

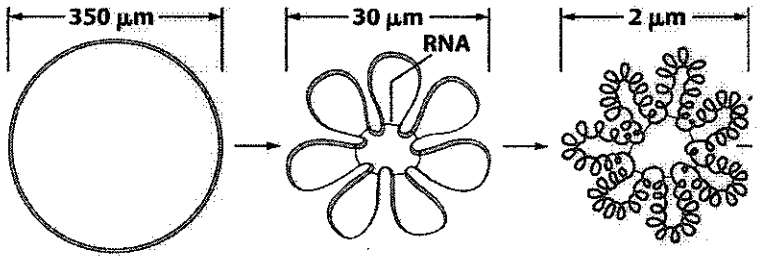
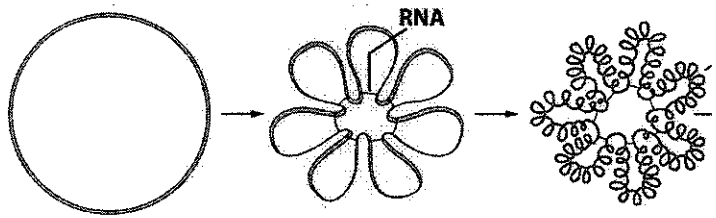


Fig. 9.15

Similar amounts of supercoiling exist in the DNA of bacterial and eukaryotic chromosomes.



The DNA found in mitochondria and chloroplasts exists in circular chromosomes that resemble those of prokaryotes.

Fig. 9.15

Like prokaryotic genomes, plastid genomes are circular

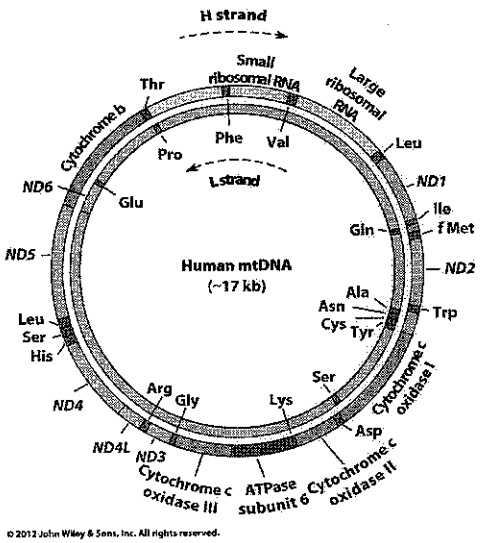


Fig. 15.21

Eukaryotic chromosomes are composed of proteins, DNA, & RNA

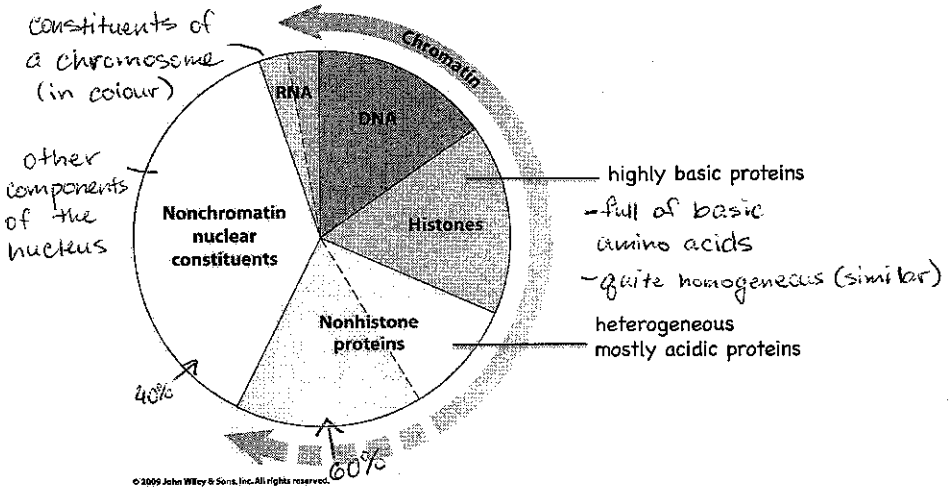


Fig. 9.16

The first level of condensation – packaging DNA as a negative supercoil into nucleosomes – made up of histone proteins

produces an 11 nm fibre – diameter of nucleosome + DNA wrapped around it

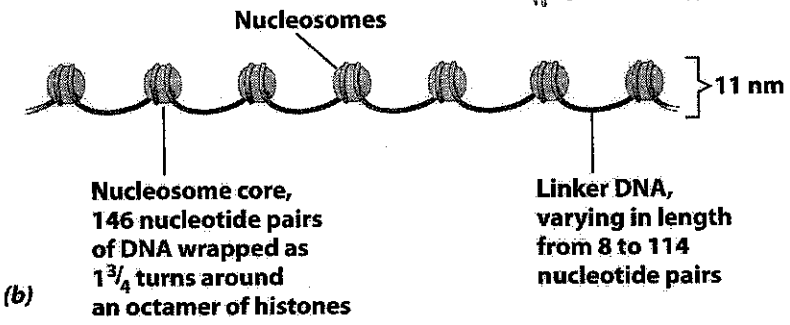
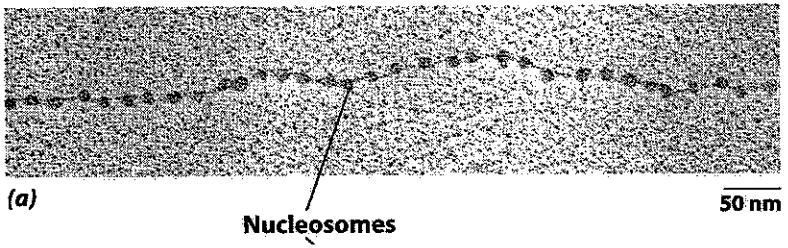


Fig. 9.17

Packaging DNA as a negative supercoil into nucleosomes



The linker region is susceptible to digestion by an endonuclease

↑
enzyme

Fig. 9.17

DNA is wrapped around a nucleosome core of 8 histone proteins and anchored by a 9th.

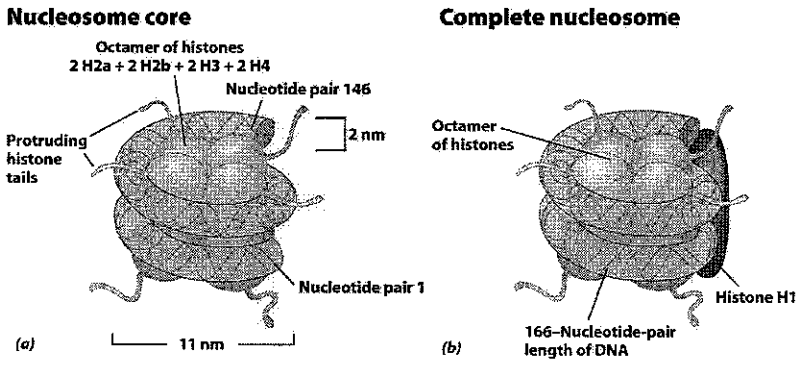


Fig. 9.18

the second level of condensation – an additional folding or supercoiling of the 11 nm fibre to produce a 30 nm fibre

driven by nucleosomal interactions

Histone H1 involved

two models that describe the substructure: the solenoid and the zig-zag models

The conformation of the 30 nm fibre depends on the methods used to visualize it

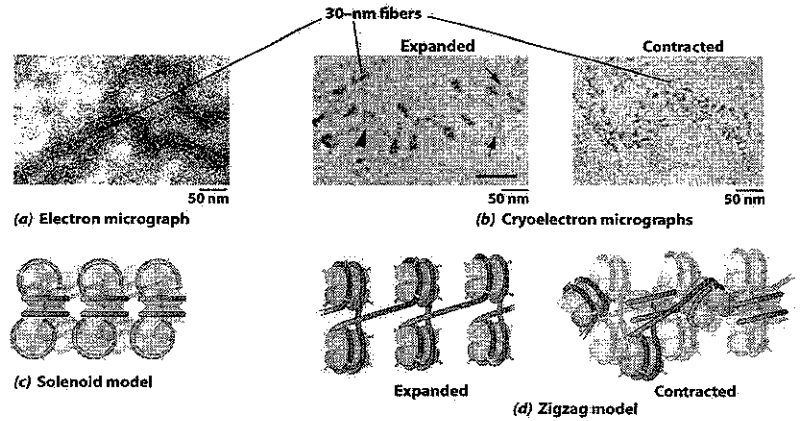


Fig. 9.21

The 30 nm fibre is the basic structural unit of the metaphase chromosome (DNA in its most condensed form)

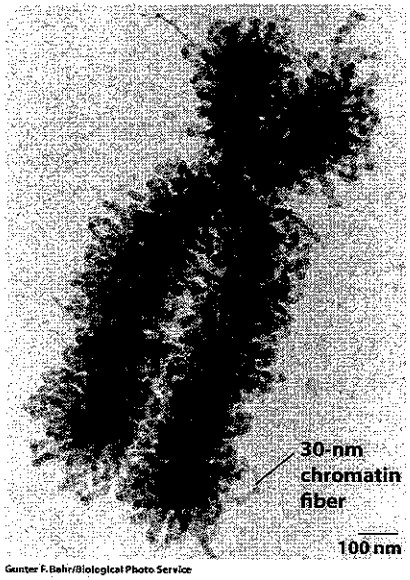
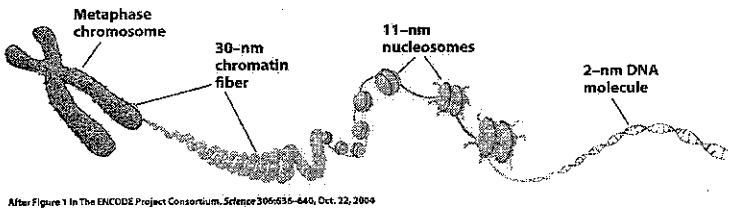


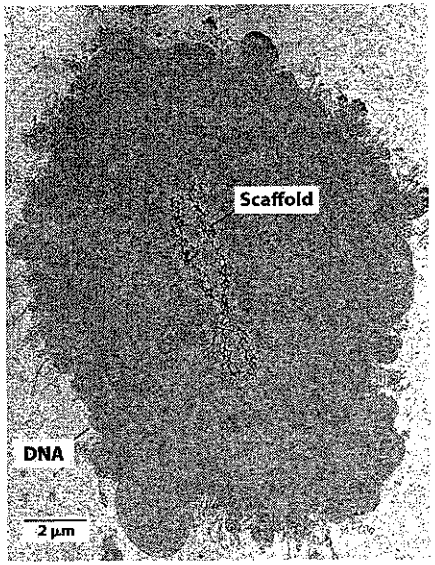
Fig. 9.20

the third level of condensation – attachment of the 30 nm fibre at many positions to a (non-histone) protein scaffold



After Figure 1 in The ENCODE Project Consortium. *Science* 306:636-640, Oct. 22, 2004

Fig. 9.23



From J.R. Paulson & U.K. Laemmli, *Cell* 12: 817-828, 1977. Copyright 1977, MIT; published by MIT Press. Original photo courtesy U.K. Laemmli.

metaphase chromosome from which all histones have been removed

Fig. 9.22