Section 5.1: DNA Structure and Organization in the Cell

SBI4UP

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What Scientists Knew Then . . .

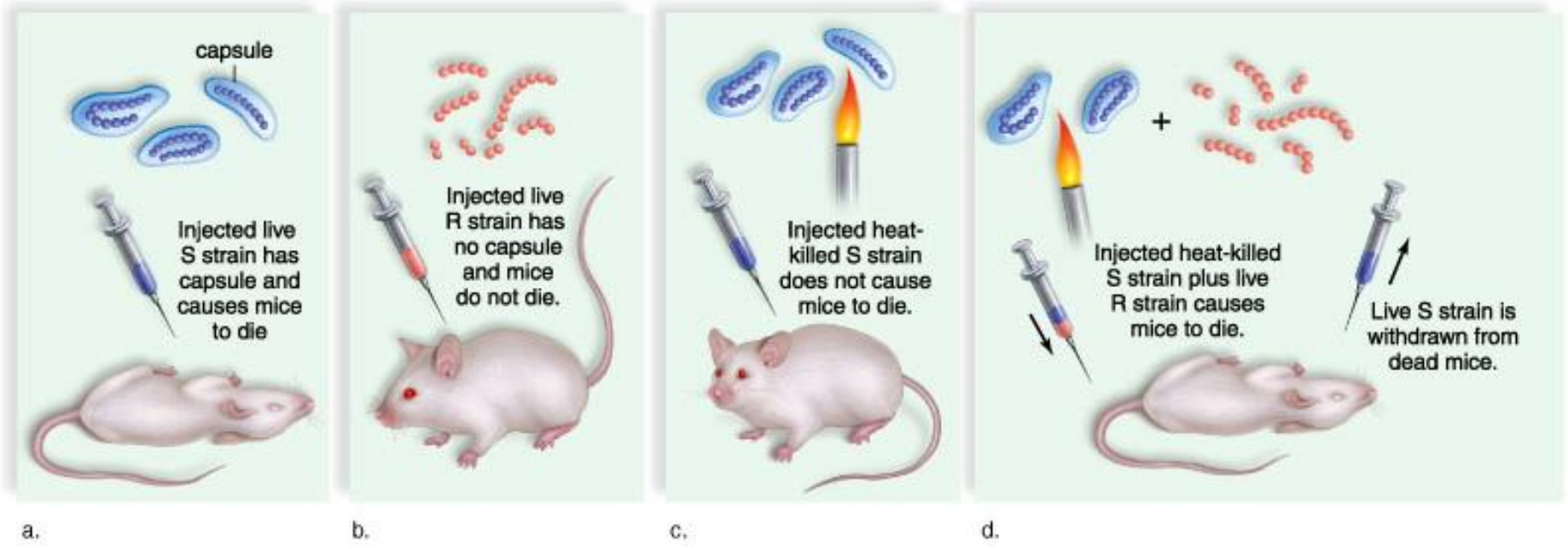
In the beginning of the 1900's, scientists had already discovered that the genetic material was found inside the chromosome within the nucleus.

Scientists also knew that the genetic material was able to in some way control the production of proteins and replicate itself. They also concluded that during the process of replication, mutations had to occur, would explain the diversity seen within species.

Scientists had also discovered the presence of proteins and nucleic acids, but they weren't sure about its chemical composition or that DNA was in fact the hereditary material.

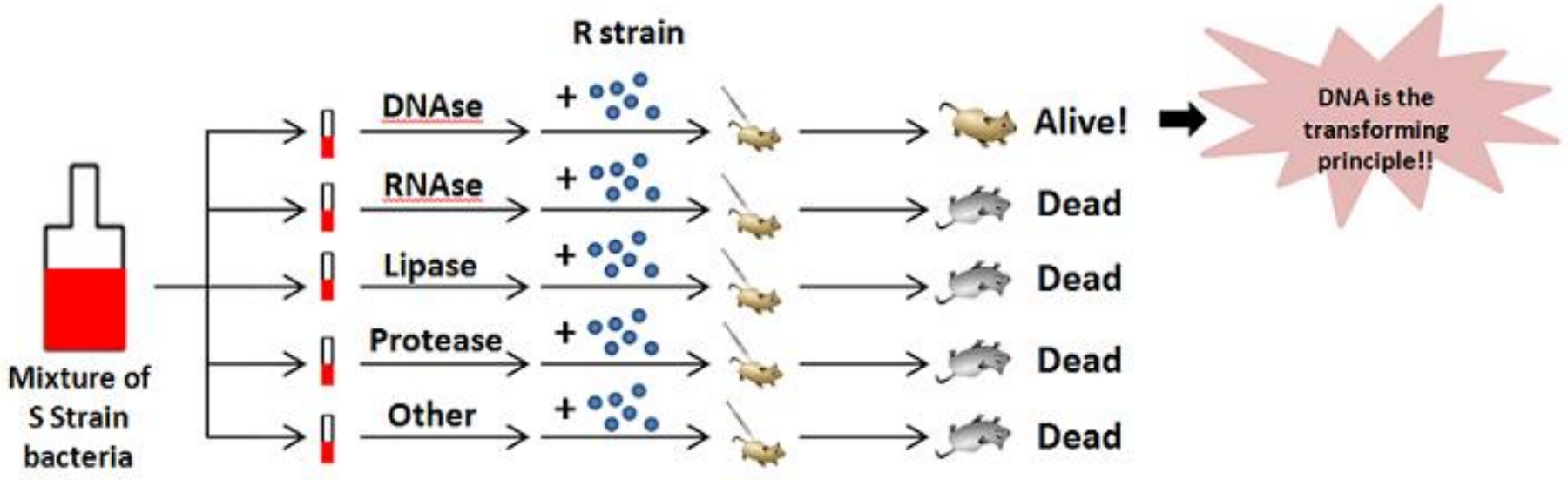
Experiment 1: DNA as Hereditary Material

When the heat killed pathogenic S. strain was mixed with the mice the non-pathogenic R. Strain, the mice died. Griffith believed this may have been to do with a transformation activity.



Experiment 2: Identifying the Transformation

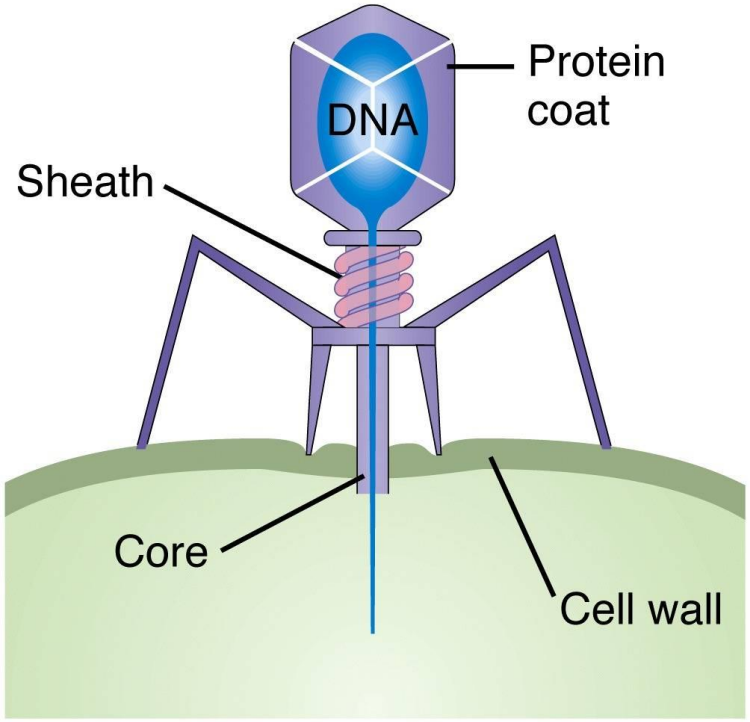
After Griffith's death, further experiments were conducted to determine whether the transformation as due to DNA activity.



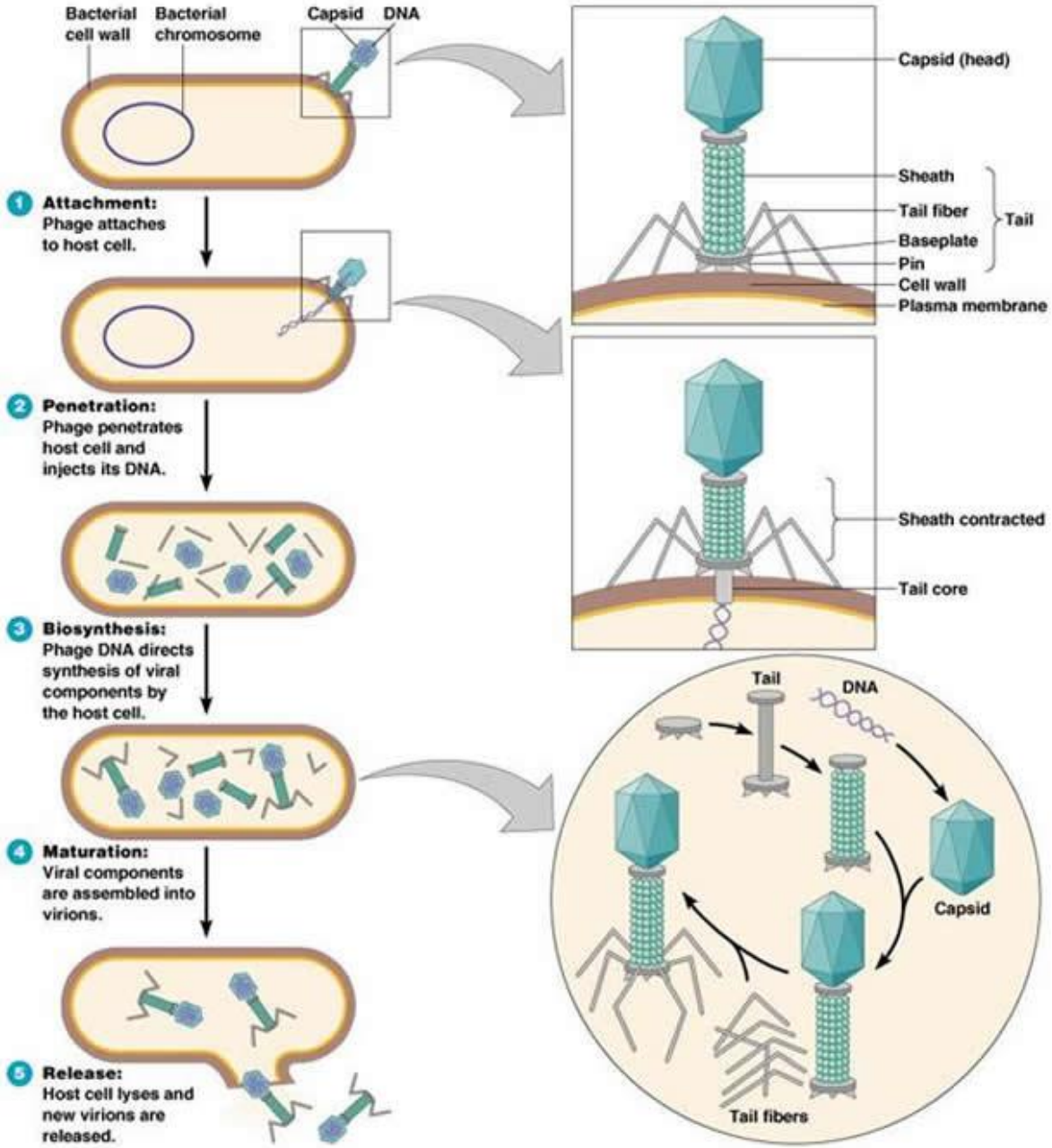
Avery and her scientists found that the only time transformation of the R. Strain did not occur is when the enzyme DNAse (destroys the DNA) was added to the sample. This suggests that DNA is responsible for the transformation activity.

Experiment 3: Identifying the Genetic Material

- The third experiment was conducted by Alfred Hershey and Martha Chase
- Bacteriophage (viruses that infect bacteria) were used in the experiment.



The DNA of the bacteriophage is found within the coated pit. When the bacteriophage attached to a bacteria, it can inject its genetic information through its core. Once, inside, the genetic information can be copied and create millions of bacteriophage.



The virus may replicate through the host cell (bacteria).

The enzyme and proteins from the host cell are used to make multiple copies and new structures for the new virus.

Experiment 3: Identifying the Genetic Material

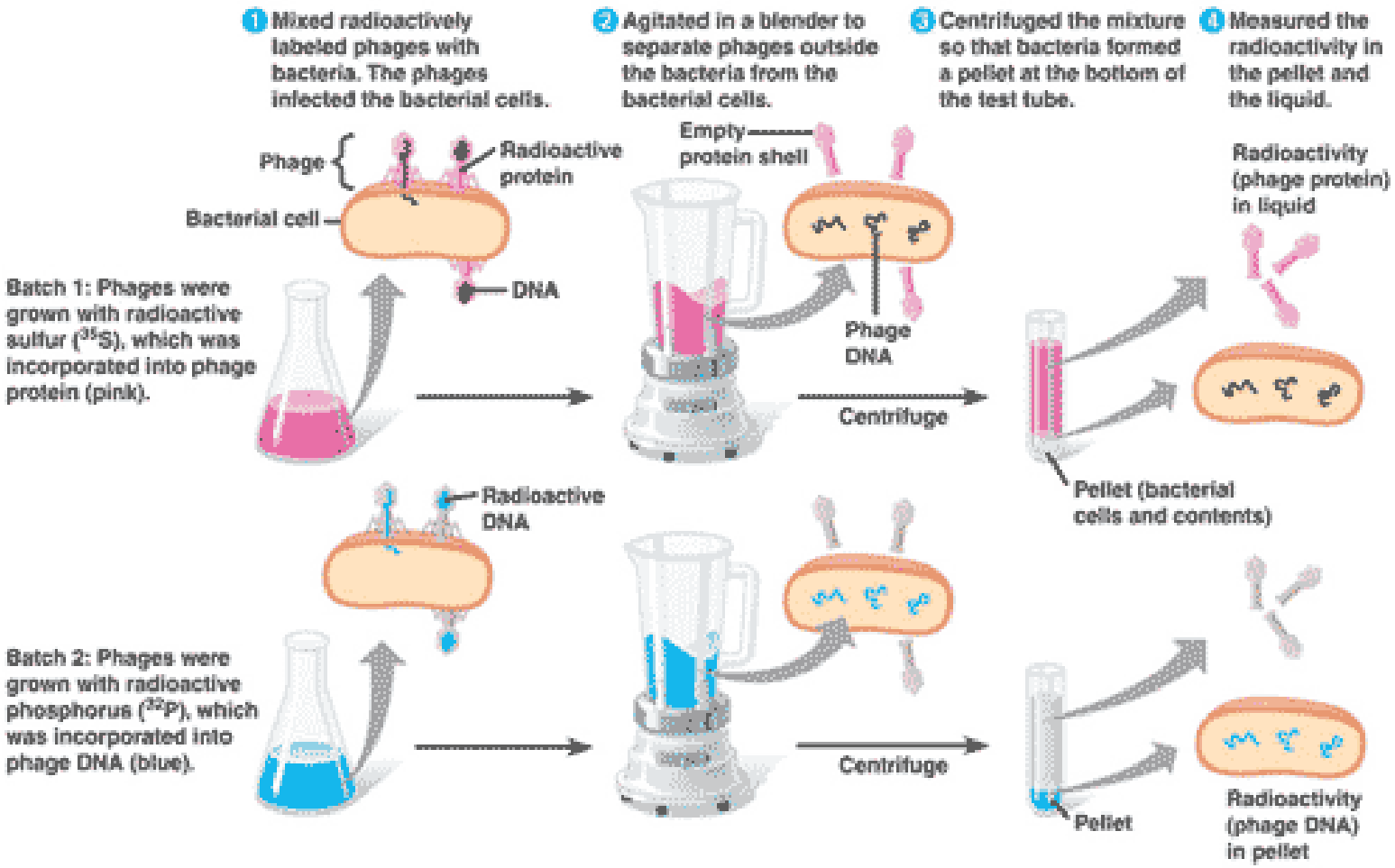
Background Information on the Study:

- The scientists wanted to know whether the virus' ability to replicate was due to the proteins in the core or the DNA

- Radioactive isotopes were used to trace the proteins or DNA in the virus.

- DNA contains ***phosphorus*** – thus radioactive P^{32} was used

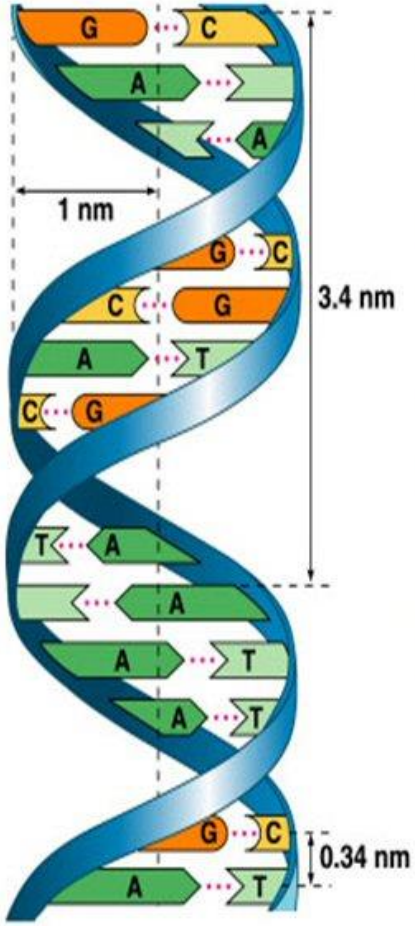
- Proteins contain ***sulfur*** – thus radioactive S^{35} was used

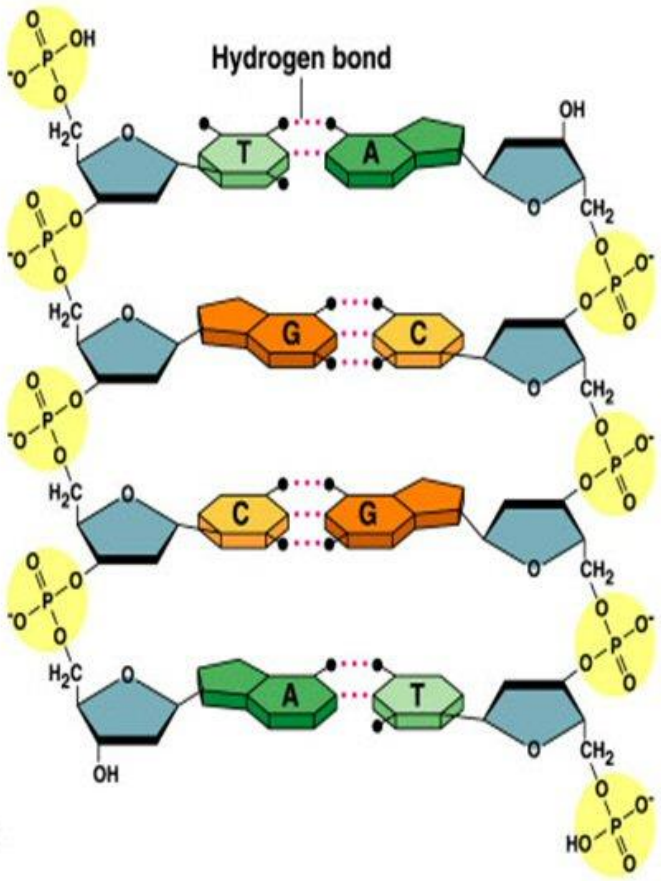


Considering that only the tagged DNA was found inside the bacteria, scientists were able to determine that it was the DNA that was responsible for infecting the bacterial stain.

Later on in the experiment, scientists found that the E.coli from batch two released phages with the tagged phosphorus inside.

Structure of DNA

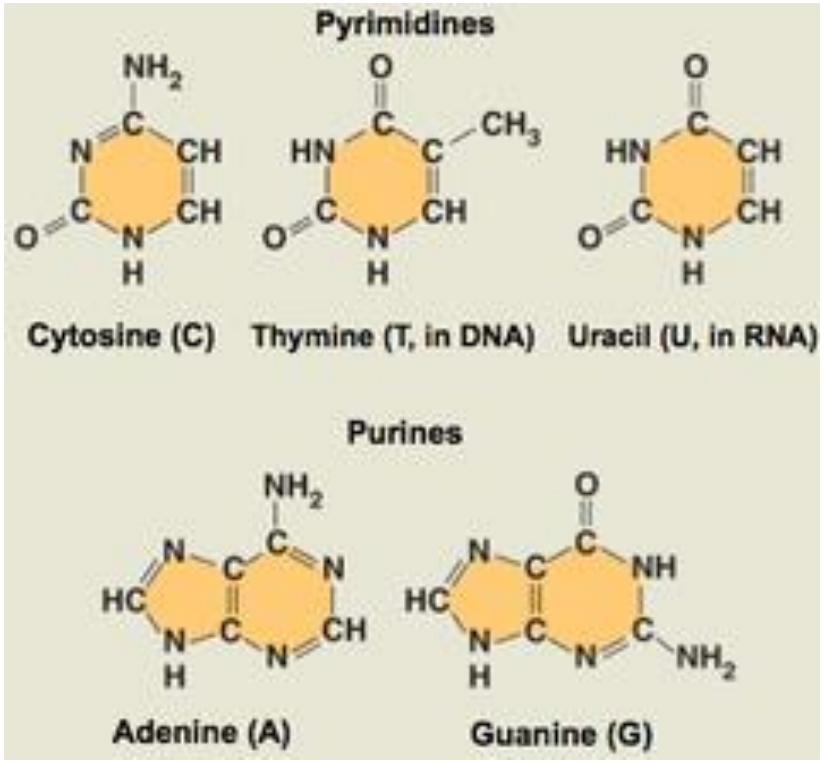




A ***nucleic acid (DNA strand)*** is composed of a phosphate, sugar and nitrogenous bases.

Chargaff had discovered that human DNA contains about 30% adenine base, whereas bacteria contained about 26%.

This was an indication that the diversity seen in organisms (i.e humans and bacteria) may be due to the structure of ***DNA and the DNA itself contained the genetic information.***

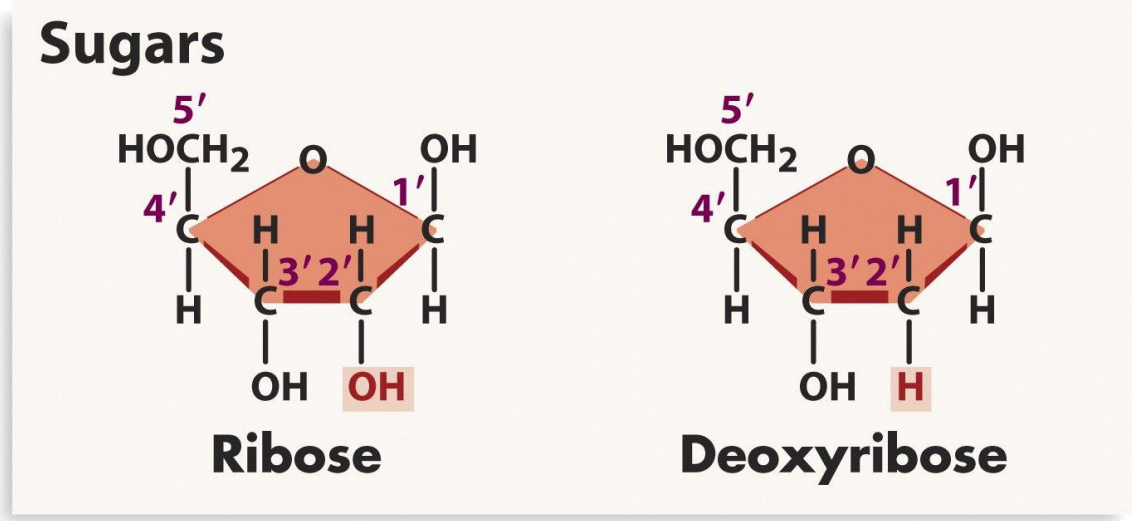


Purines *can only combine with* ***pyrimidines****.*

More specifically: A – T and C- G

The sugar found in the DNA backbone, does not contain a hydroxyl group on the 2nd carbon.

The sugar of RNA, contains a hydroxyl group on the second carbon.



Chargaff's Rule

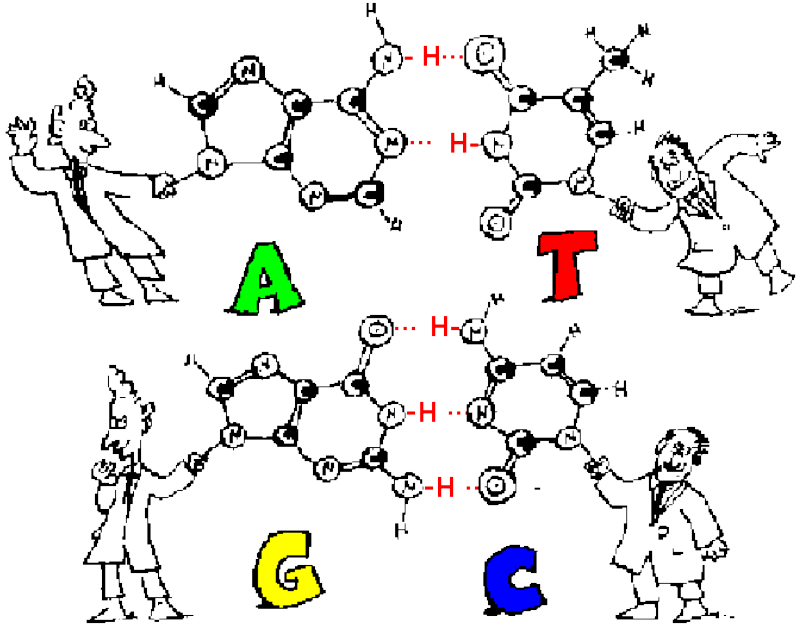
Percentages of Bases in Four Organisms				
Source of DNA	A	T	G	C
Streptococcus	29.8	31.6	20.5	18.0
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Human	30.9	29.4	19.9	19.8

Thus Chargaff discovered that purine only combined with pyrimidines. But more specifically that:

A = T

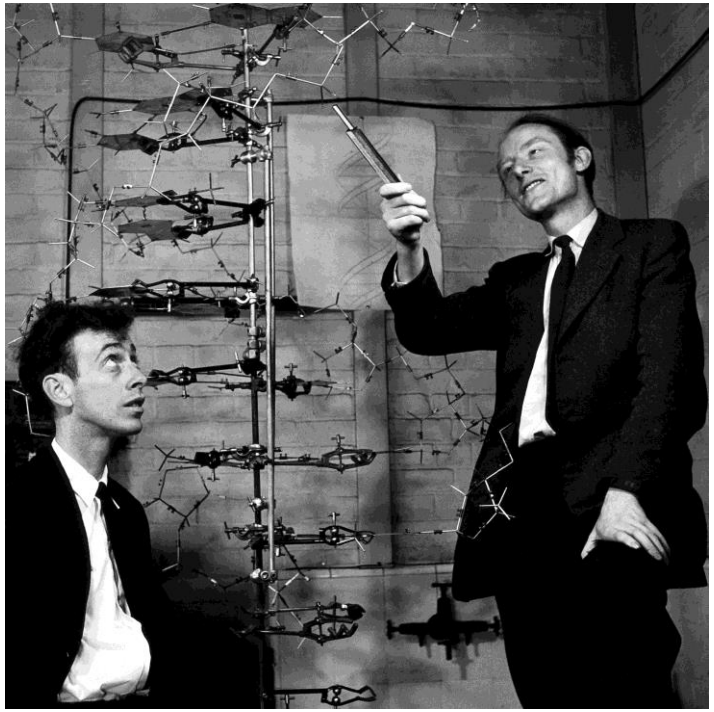
C = G

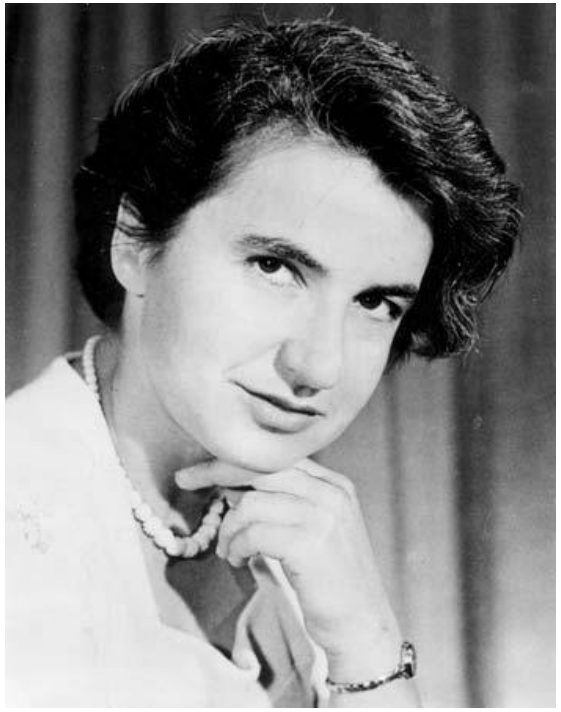
It was found that the amount of adenine in the DNA sample was almost equal to the amount of thymine, and the same applied for guanine and cytosine.



DNA Structure and Inheritance

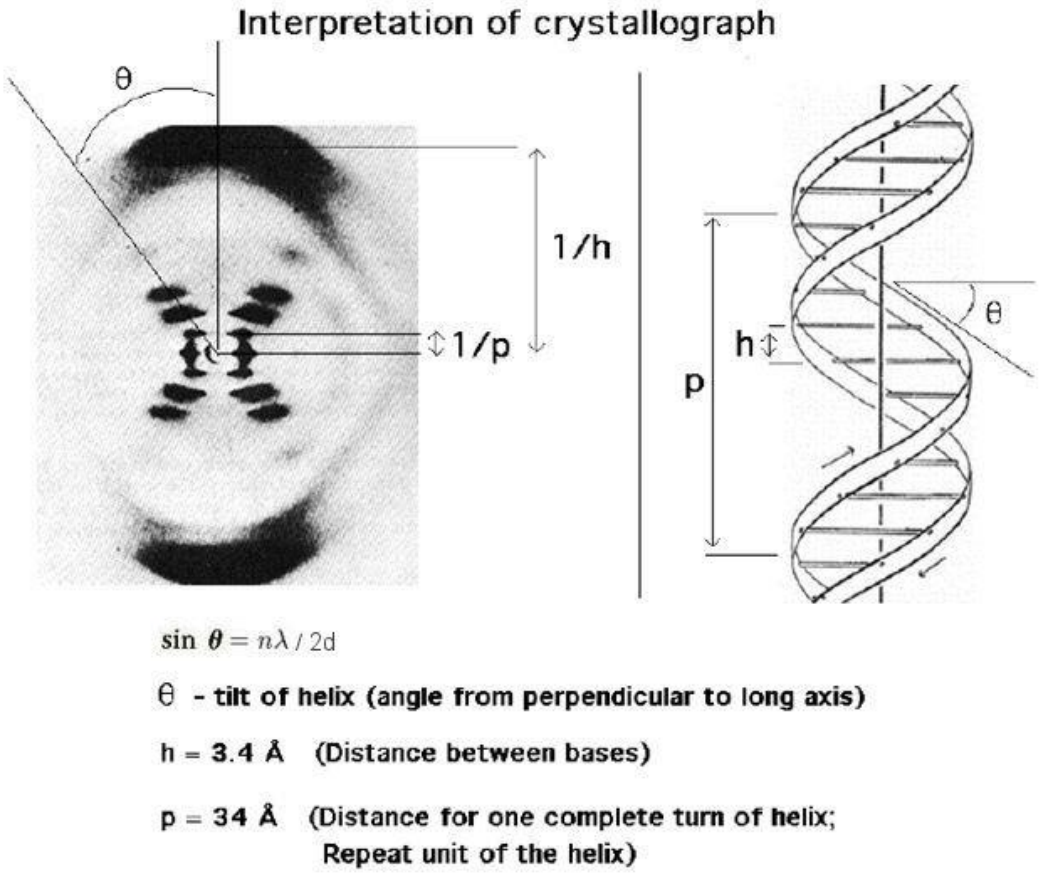
Watson and Crick were the scientists recognized for discovering the structure of DNA.





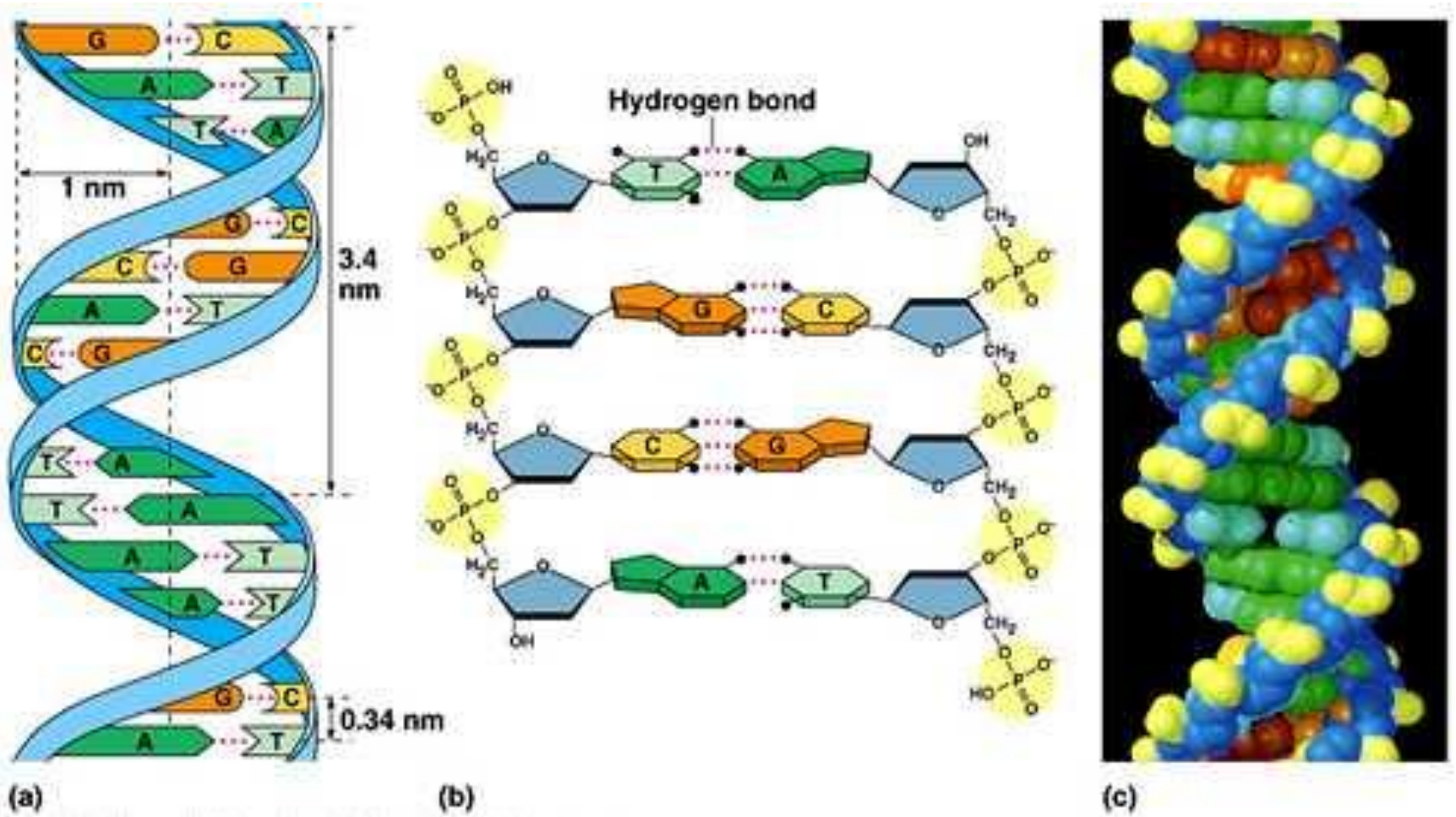
Rosalind Franklin was an X-ray crystallographer that had taken an X-ray of the DNA structure.

DNA Structure and Inheritance



At first, Watson and Crick took credit for the X-ray and used it to determine the structure of DNA.

Through mathematical equations, scientists were able to see that DNA was a double helix.



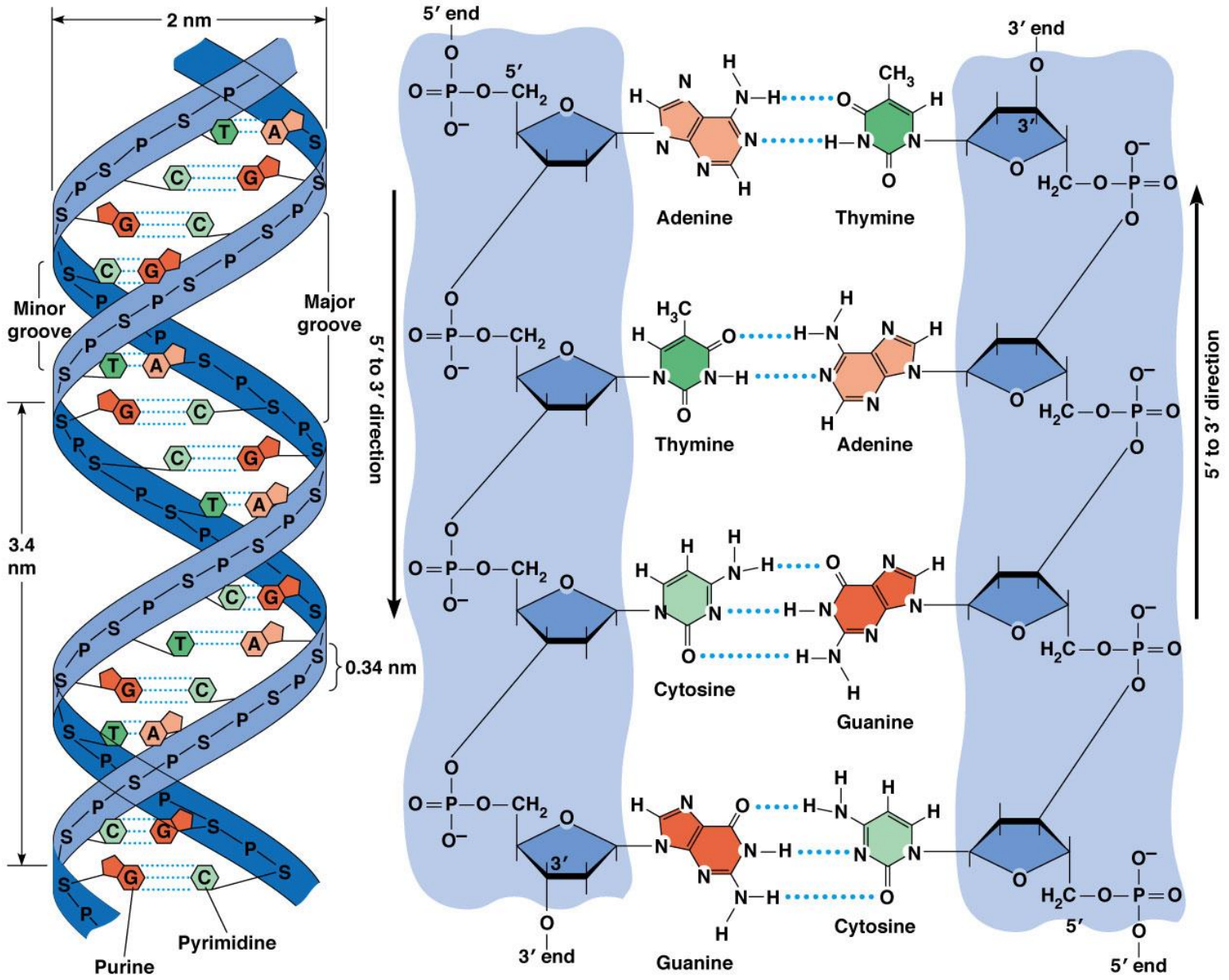
Rosalind discovered that nitrogenous bases were located within the helix due to hydrophobic properties and that the backbone consisted of phosphate and sugar (hydrophilic was located on the outside).

DNA Structure

1. DNA is a double helix that has complementary base pairing.

2. Two nucleic acid chains twist around one another and are connected by hydrogen bonds between the nitrogenous bases.

3. Both are antiparallel to one another such that the 5’ of one strand is across from the 3’ end of another.



(a) Double helix

(b) Antiparallel orientation of strands

Checking for Understanding

If a DNA molecule contains 20 percent of A, approximately what percentage of G is present?

A.) 20 %

B.) 40 %

C.) 30 %

D.) 60 %

E.) 50 %

Checking for Understanding

What did Rosalind Franklin's X-ray diffraction images reveal about the structure of DNA?

A.) DNA is a polymer of nucleotides

B.) Each nucleotide has a deoxyribose sugar

C.) DNA is a helical structure

D.) DNA is composed of adenine, thymine, cytosine and guanine

E.) The amount of adenine is the same as thymine, and the amound of guanine equals the amount of cytosine

Checking for Understanding

In a double-stranded DNA molecule, the complementary strand to 5'-AAACGCTT - 3' is which of the following?

A.) 5' - TTTGCGAA - 3'

B.) 5' - GGGTATCC - 3'

C.) 3' - TTTCGCAA - 5'

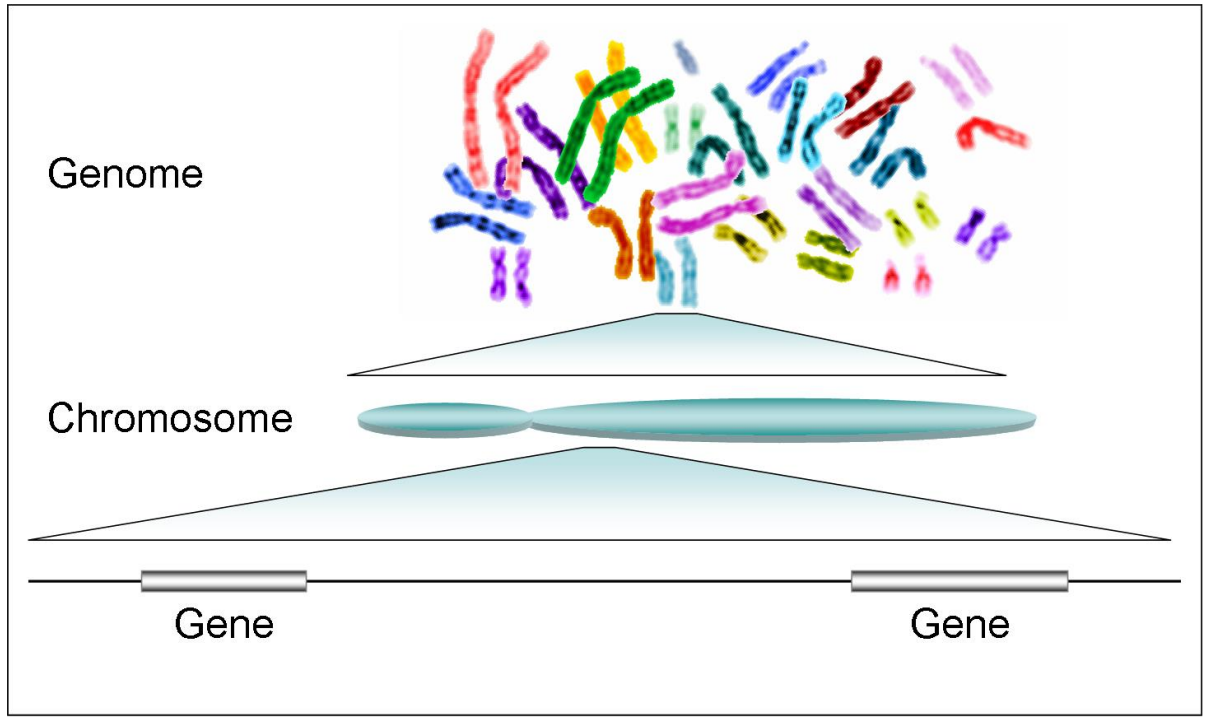
D.) 3' - GGGTATCC - 5'

Homework

Textbook: **pg. 207 # 2,3,4 & 6 & pg. 212 # 7 - 9**

Organization of the Genetic Material

Genome: the complete genetic makeup of an organism. All of the 23 chromosomes found in the cell, make up a person's genome.



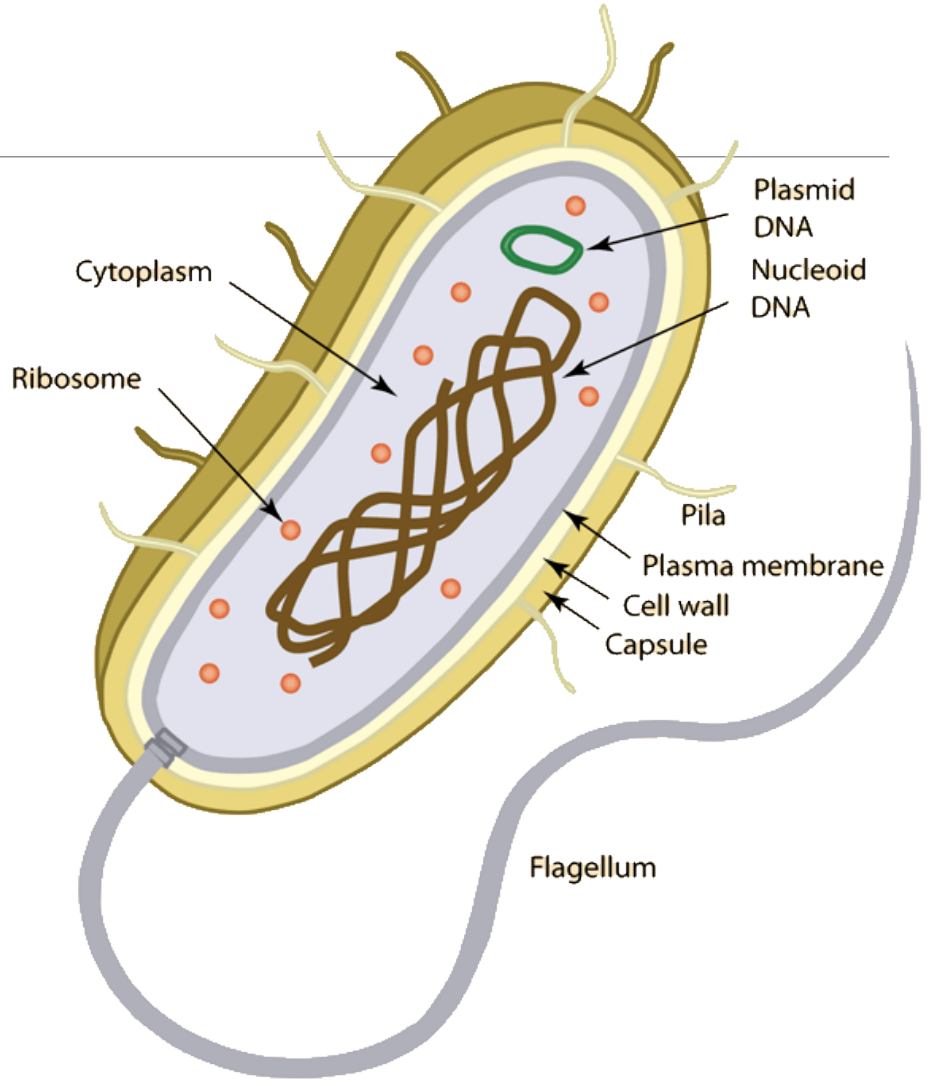
Gene: *nitrogenous bases in the DNA sequence that code for a particular trait.*

All genes code for RNA sequences which in turn are made into proteins. These proteins will have specific functions that contribute to the overall functioning of the cell.

Genetic Material in Prokaryotes

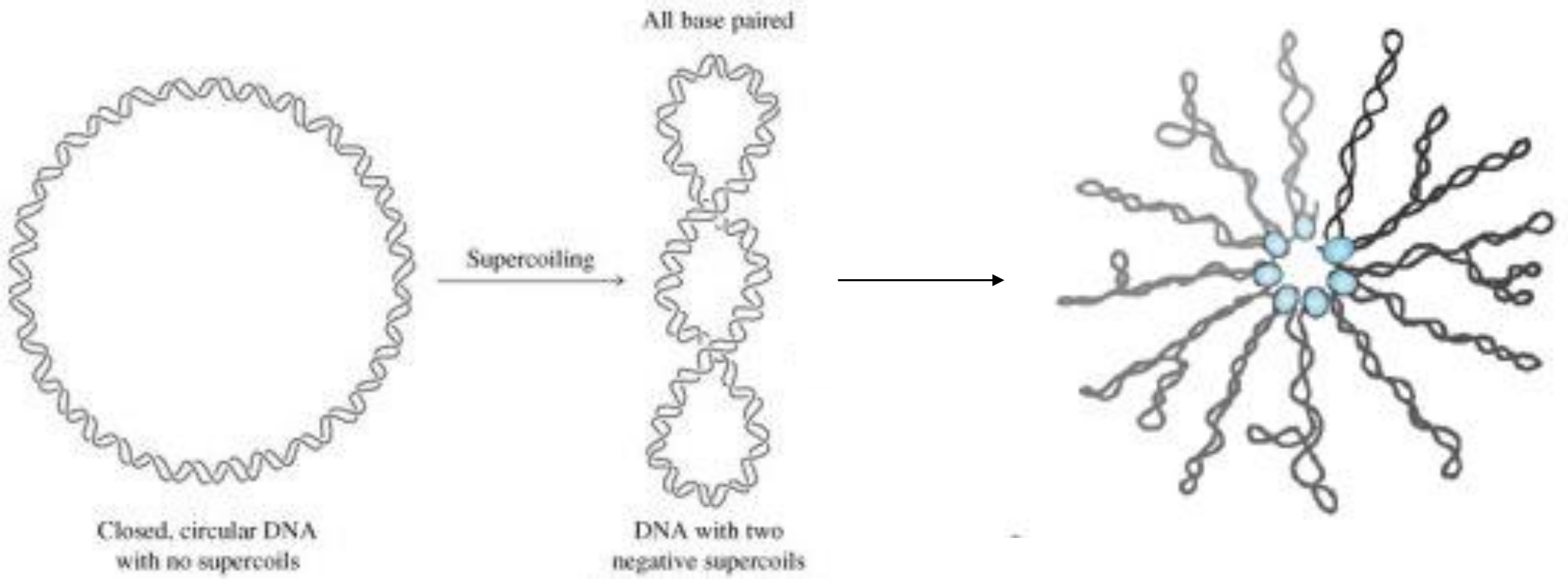
The E.coli's DNA is circular and double stranded. Considering that there is no nucleus in the bacteria, the chromosomes are free floating in the nucleoid region.

In order to fit all of the DNA into the bacteria, supercoiling is necessary.

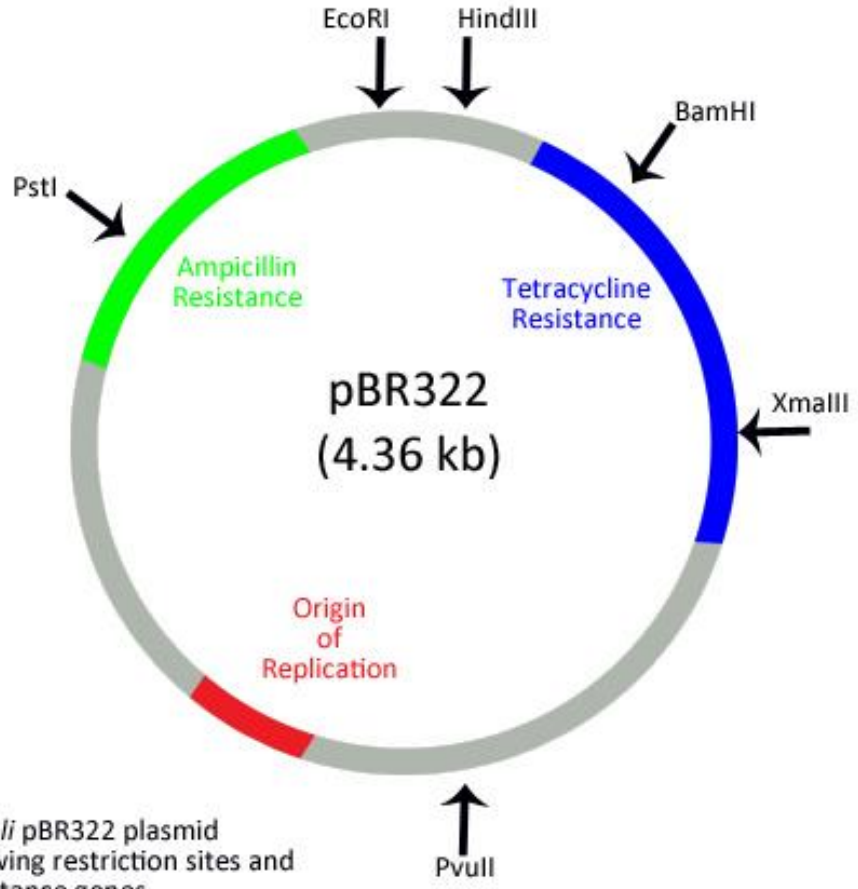


Prokaryotes - DNA Supercoiling

In order to fit all of the DNA into the compact structure of the bacteria, the circular DNA must supercoil to make its structure smaller. Supercoiling compacts the DNA by 10 fold.



Prokaryotes - Regulatory Sequences



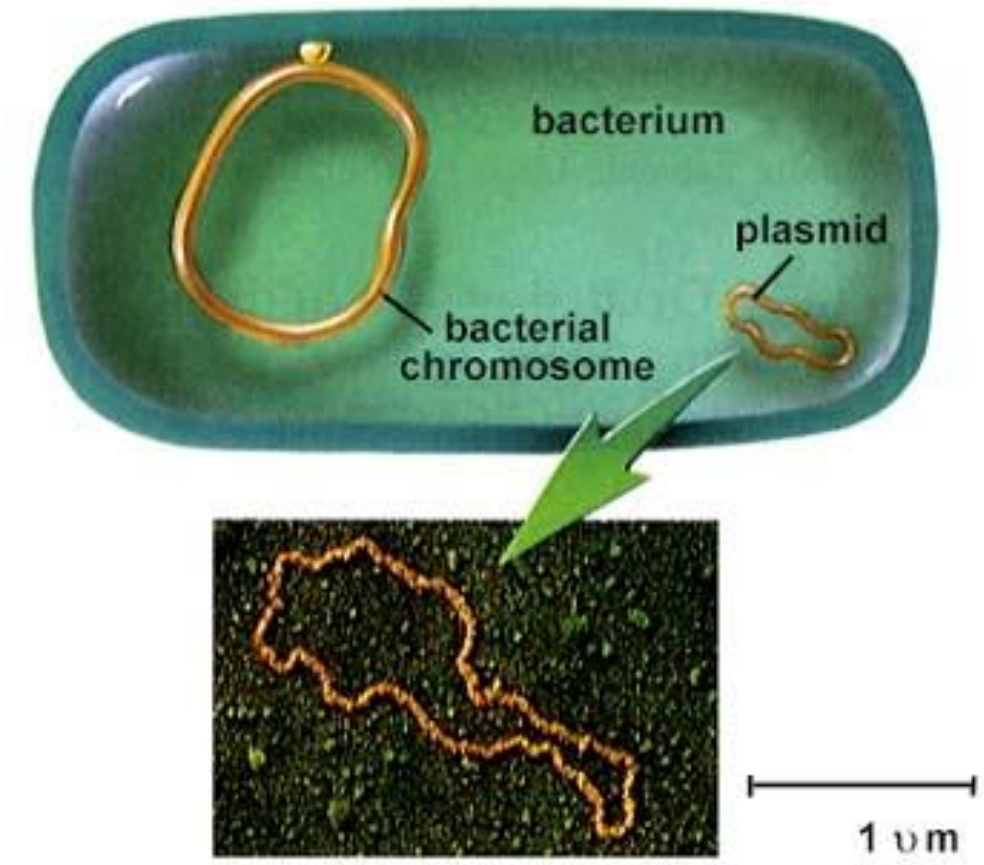
E. coli pBR322 plasmid showing restriction sites and resistance genes.

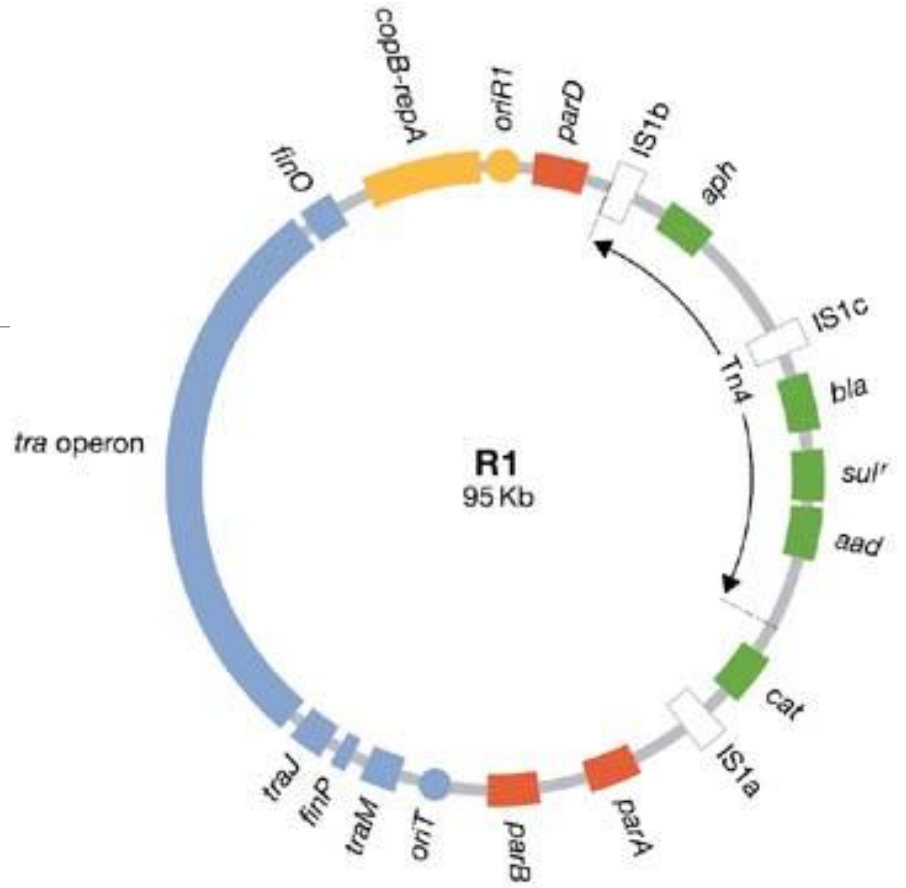
Most of the genes found in prokaryotes are essential genes. They only contain one copy of each gene, making them haploid organisms.

The genes are regulated by regulatory sequences.

Regulatory Sequences: a sequence of DNA that regulates the activity of a gene.

Prokaryotes - Plasmids





Plasmids are circular DNA molecules that are NOT found in the nucleoid and do not contain essential genes.

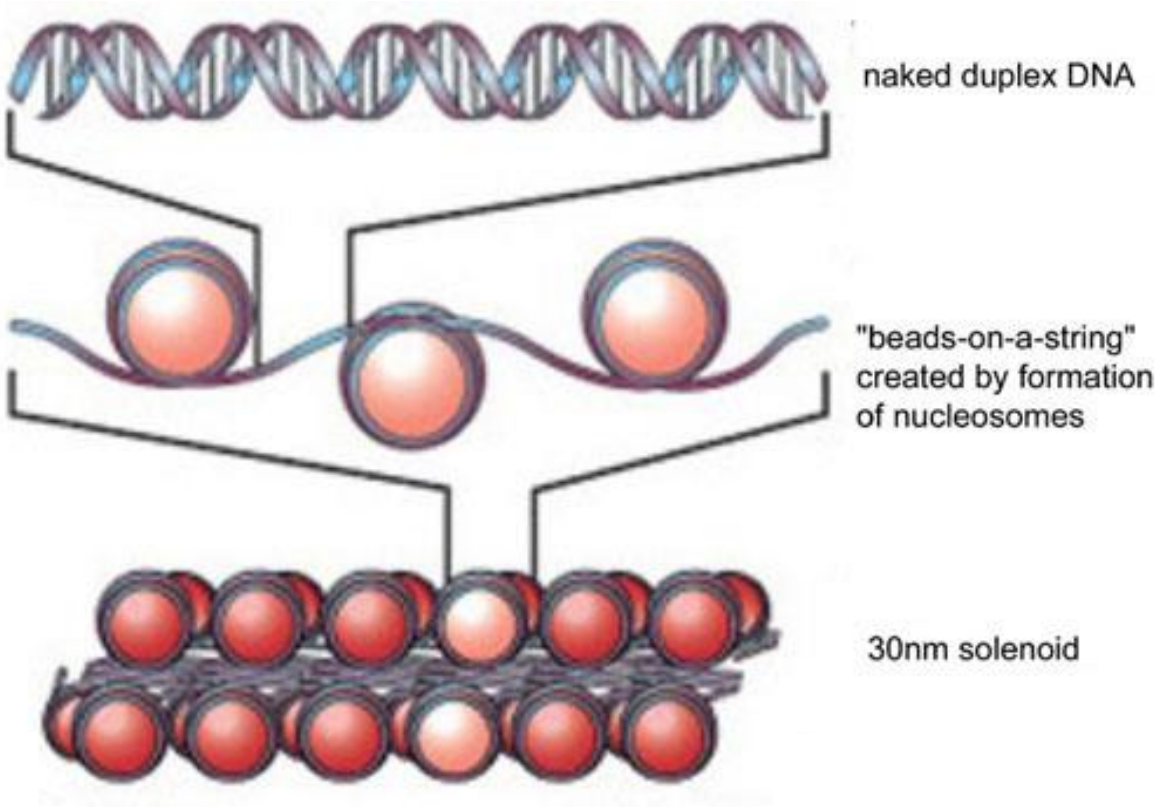
The plasmid is copied and transmitted to the new bacterial cells during cell division.

DNA of Eukaryotic Cells

There are **four different levels of organization** that enable the 2m DNA to fit into a 4µm nucleus:

A) 1st level of organization: DNA wraps around the histones to form a nucleosome

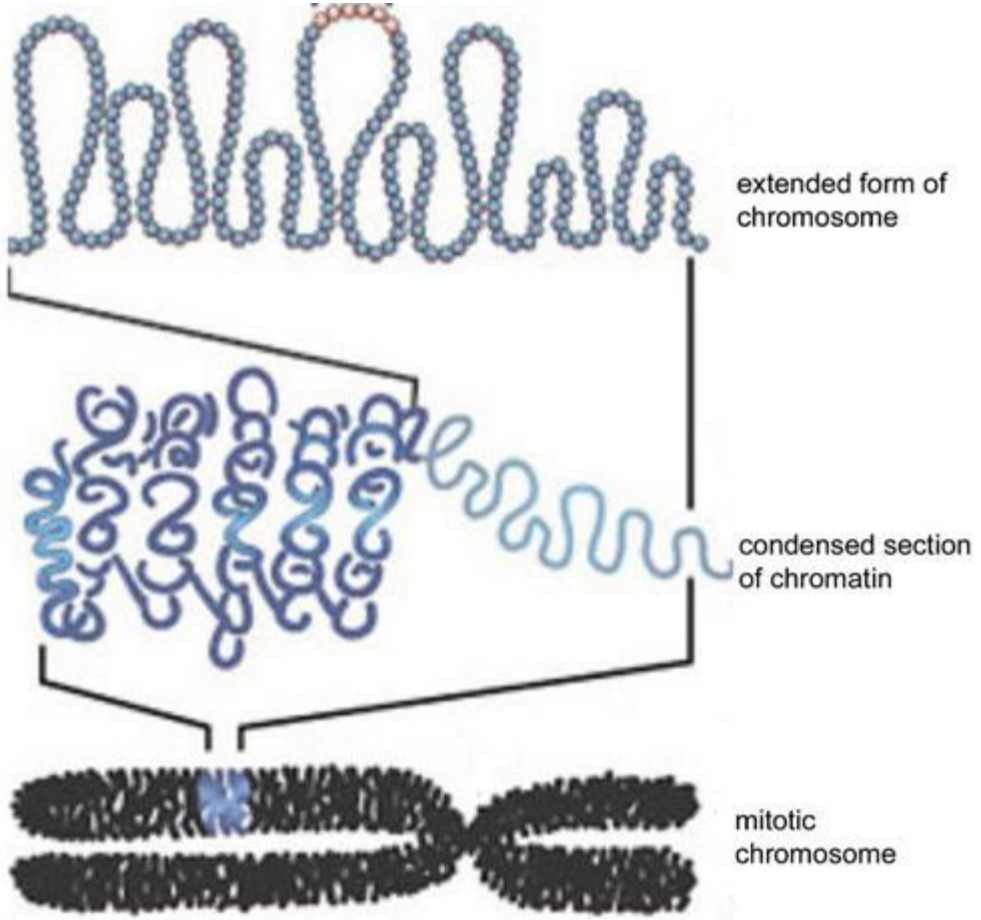
B) 2nd level of organization: The nucleosomes wrap around one another to form a chromatin fiber.



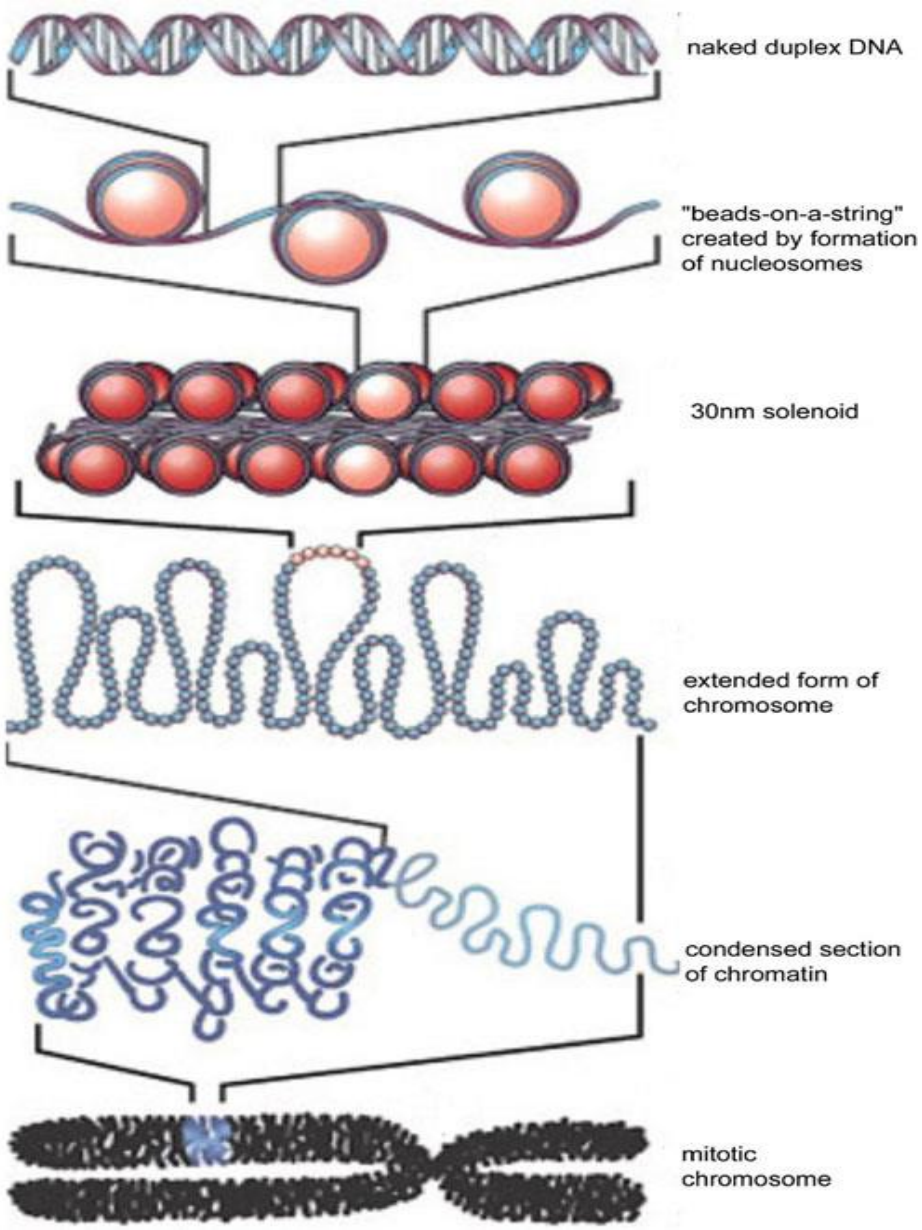
DNA of Eukaryotic Cells

C) 3rd level of organization: The fibers create loops with the help of scaffold protein to further compact the structure.

D) 4th level of organization: The scaffold will fold into a more compact structure (i.e chromosome)



Summary of all four levels of DNA organization



Variation in Eukaryotic Genomes

1) Diploid vs. Haploid:

2) Organization of genes:

3) Size and number of genes:

4) Coding differences:

Checking for Understanding

In prokaryotic genomes, which regions determine when certain genes and the associated cell functions?

A) genomic sequences

B) Regulatory sequences

C) plasmids

D) chromatin

E) nucleoids

Checking for Understanding

1) Explain how the two DNA strands are antiparallel.

2) Explain how 2m of DNA I able to fit into a 4um cell nucleus.

Homework

Textbook pg. 218 # 1, 2, 6, 8, 9 & 14