SBL100

Introduction to genetic engineering

Lecture 1

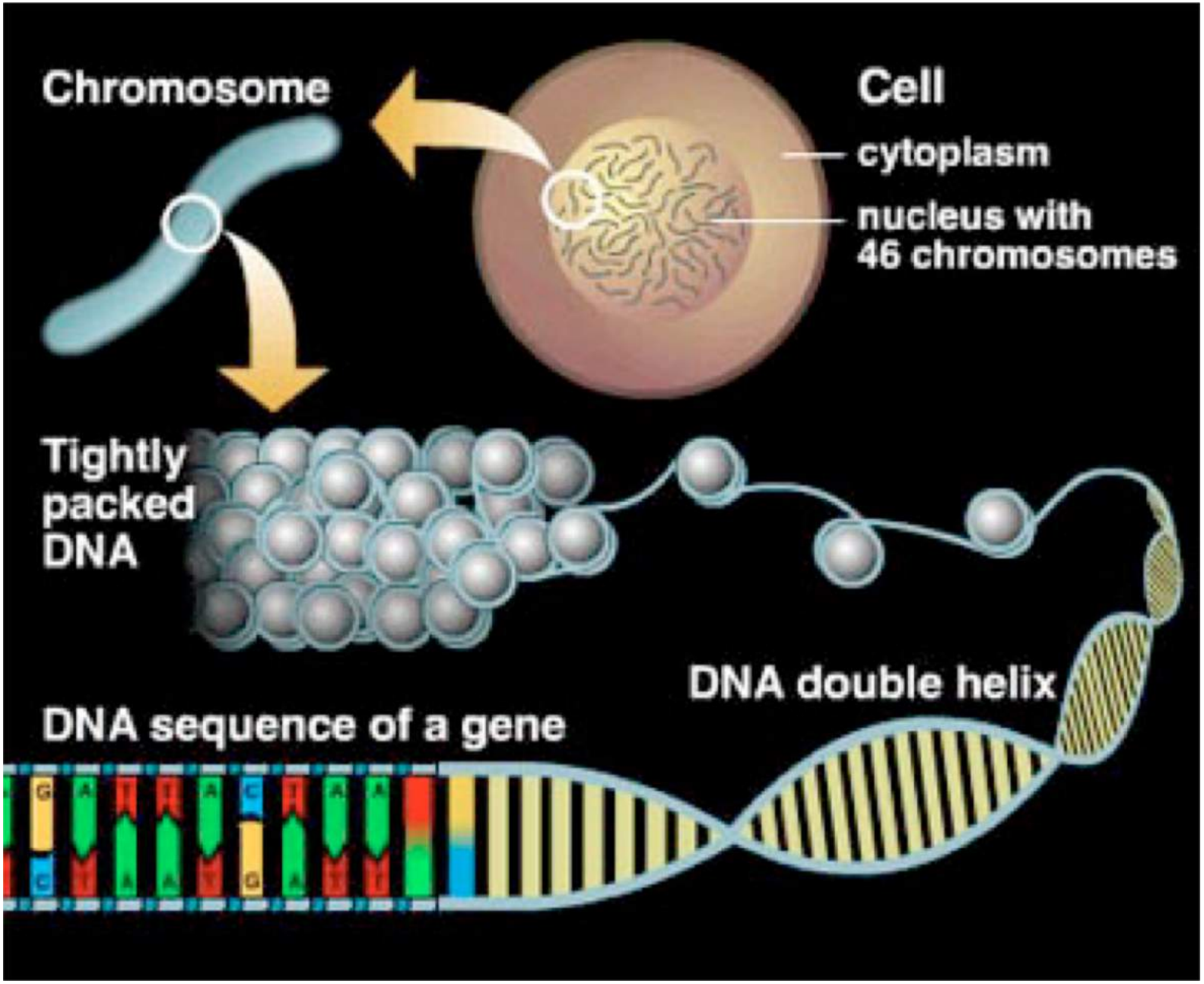









Nuclear composition in cell



Packaging of DNA into Chromosomes

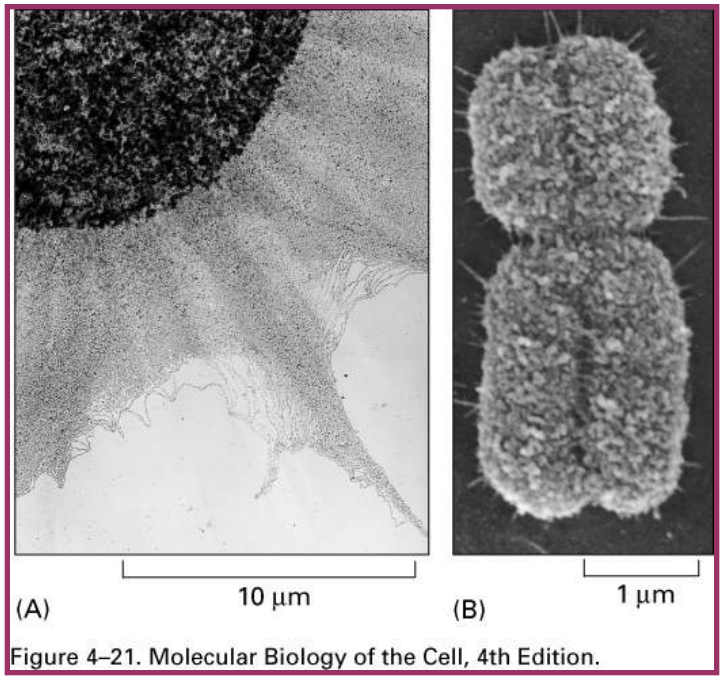
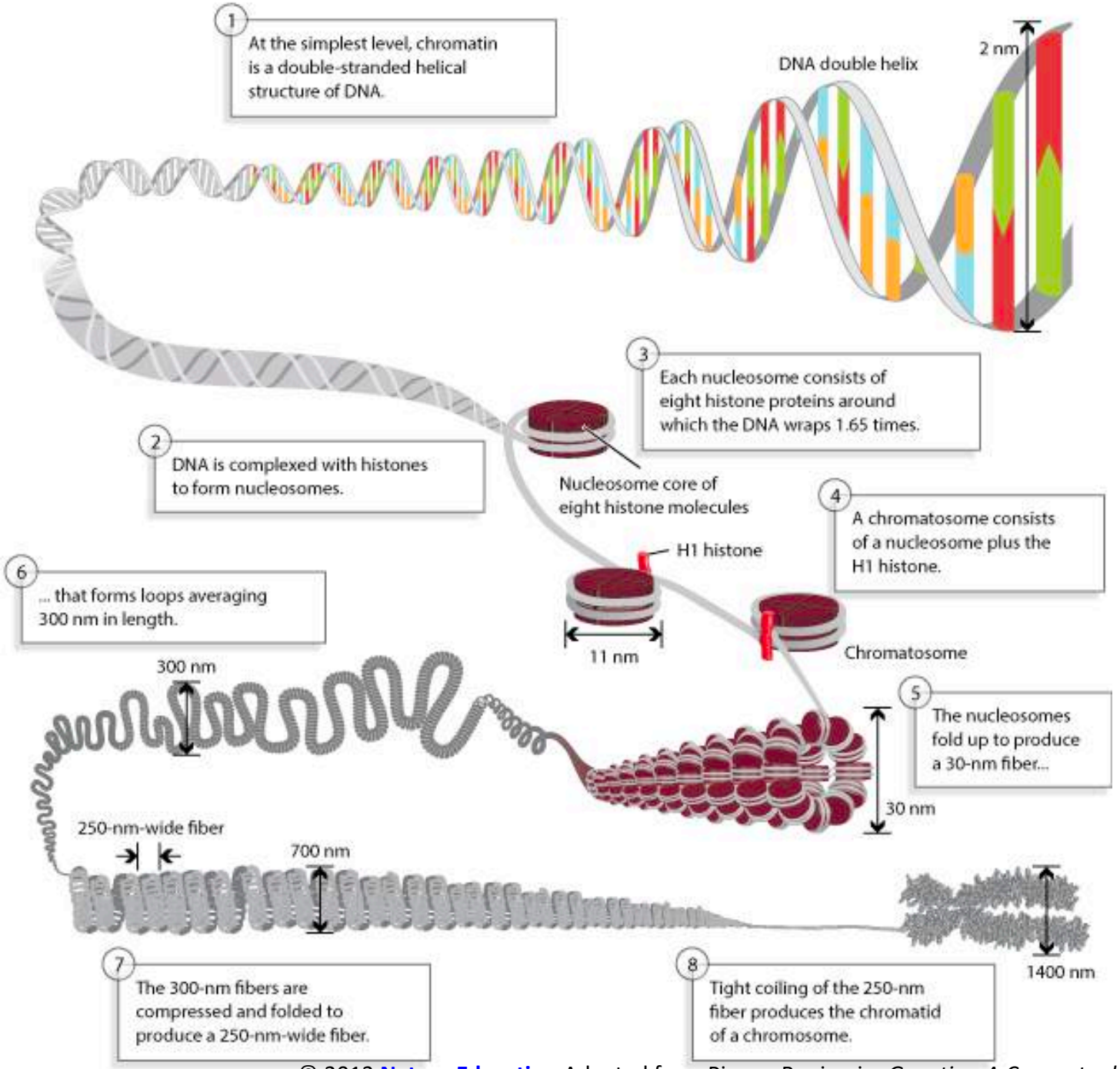


Figure 4–21. Molecular Biology of the Cell, 4th Edition.

Challenges of Packaging DNA

- How to get 2 meters of DNA into nucleus of 6 um
- Packaging accomplished with help of proteins
- Must be compacted in manner that still allows for it to be accessed by enzymes that govern replication, transcription, and repair



Five levels of chromosomal packaging

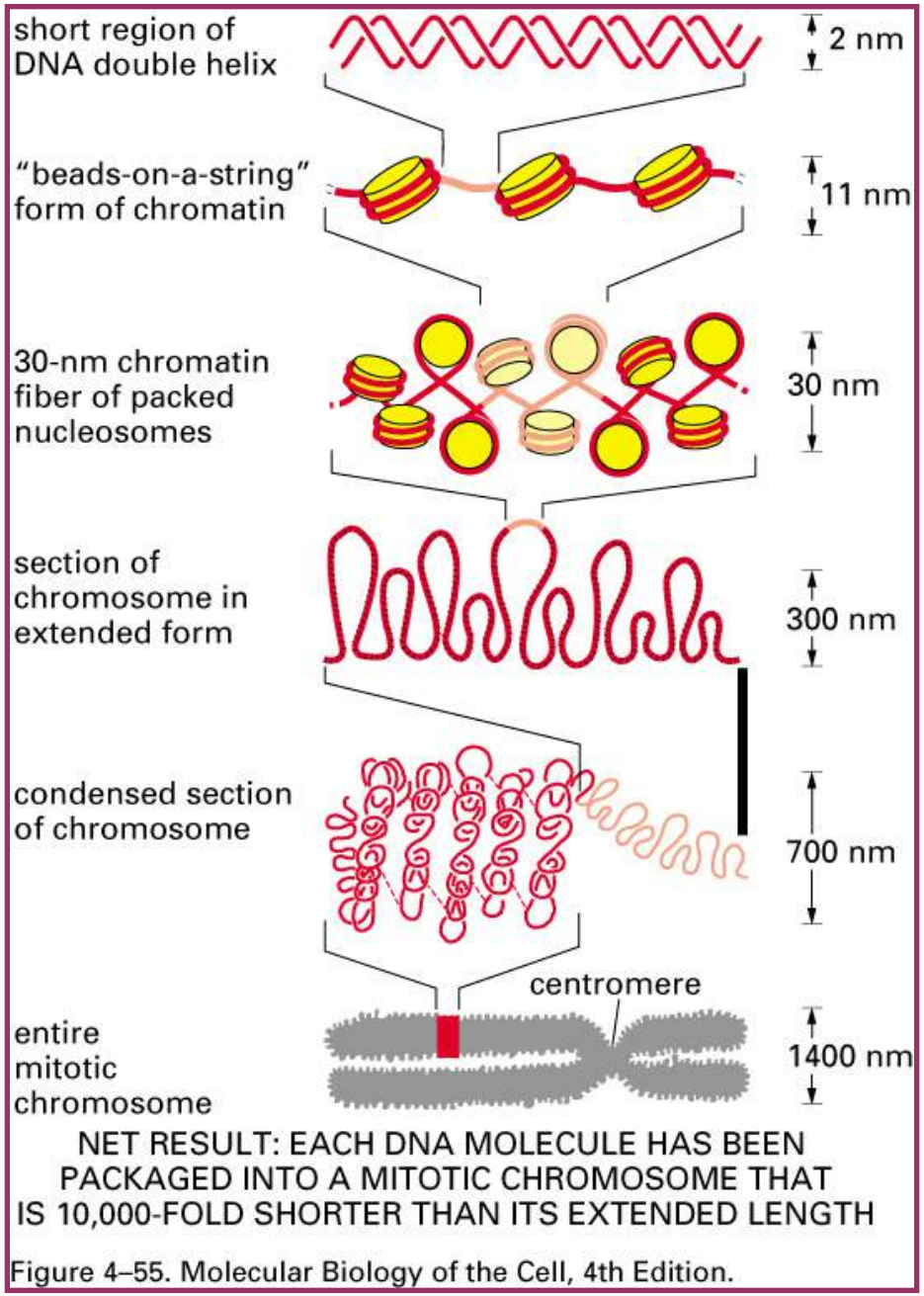


Figure 4–55. Molecular Biology of the Cell, 4th Edition.

Genome and Chromosomes

	Genome size (base pairs)	Chromosome number (*n*)
Amoeba dubia	670,000,000,000	Several hundred
Trumpet lily (*Lilium longiflorum*)	90,000,000,000	12
Mouse (*Mus musculus*)	3,454,200,000	20
Human (*Homo sapiens*)	3,200,000,000	23
Carp (*Cyprinus carpio*)	1,700,000,000	49
Chicken (*Gallus gallus*)	1,200,000,000	39
Housefly (*Musca domestica*)	900,000,000	6
Tomato (*Lycopersicon esculentum*)	655,000,000	12

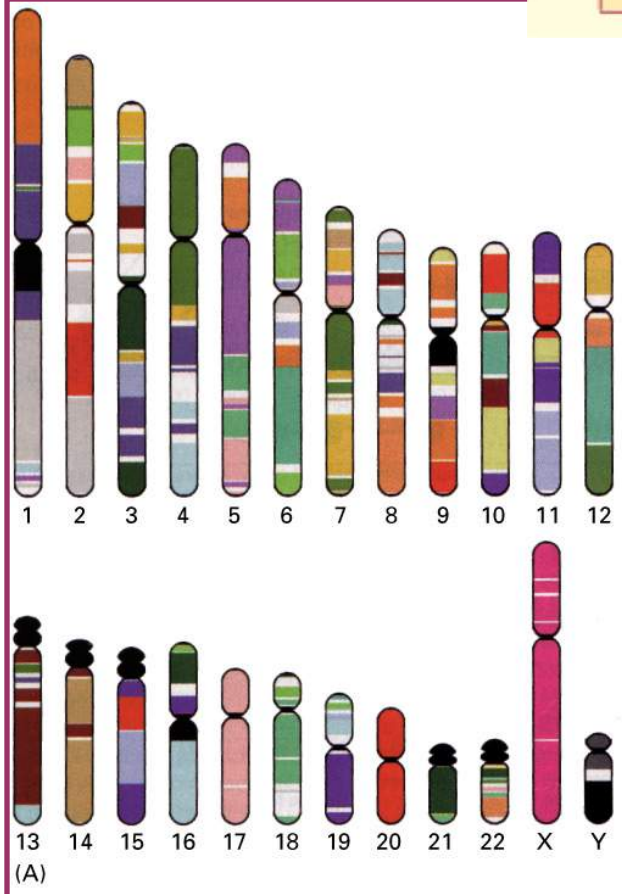


Figure 4–18 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

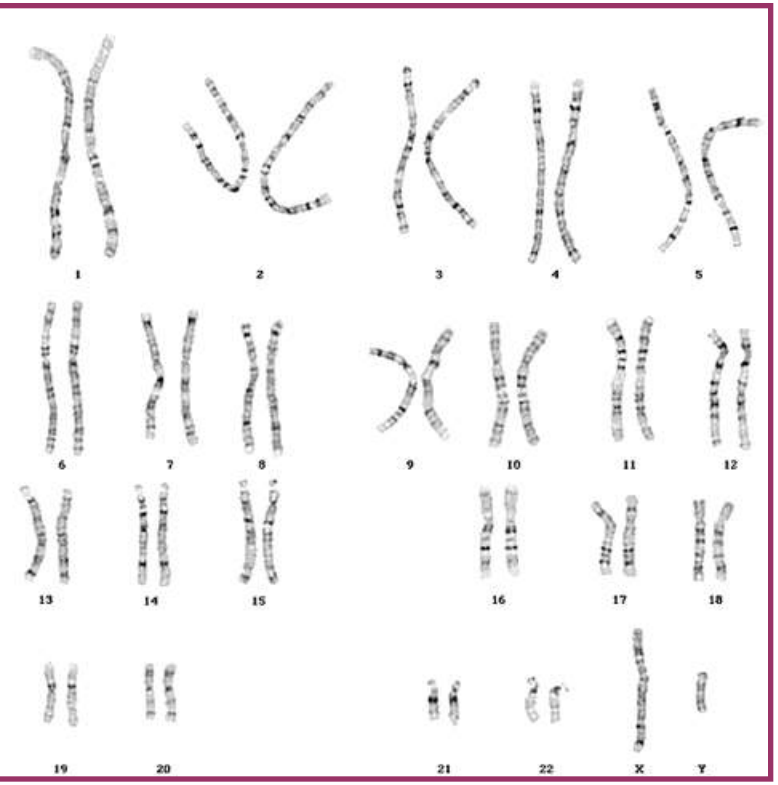
Human Chromosomes

- Human DNA 3.2 x 10^9 bases distributed over 23 pairs of chromosomes
- Each human cell contains 46 chromosomes.
- 22 pairs of homologous chromosomes AND one pair of sex chromosomes, X and Y (XX in females; XY in males)

Packaging of DNA into Chromosomes

DNA is packaged into a set of chromosomes

- DNA divided into set of chromosomes
- Chromosome= single DNA molecule and proteins associated with it



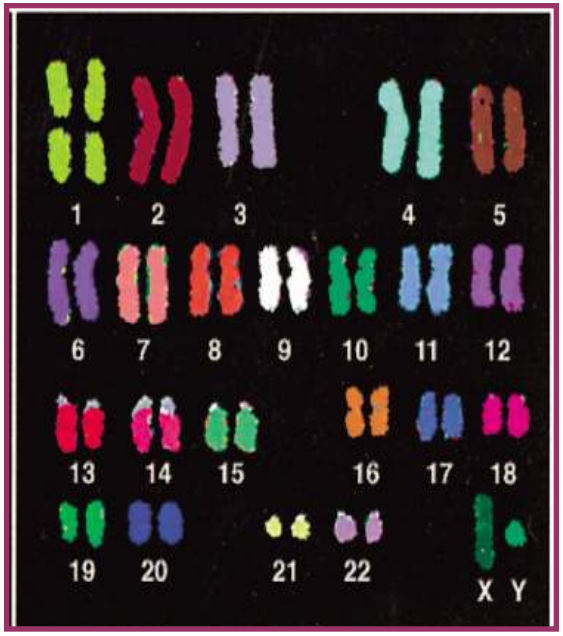
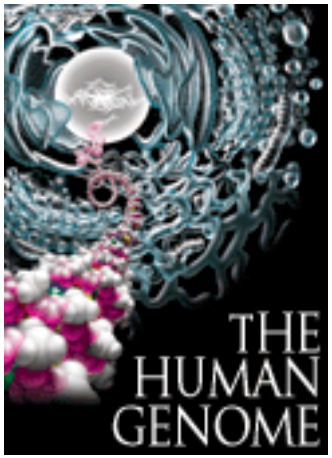
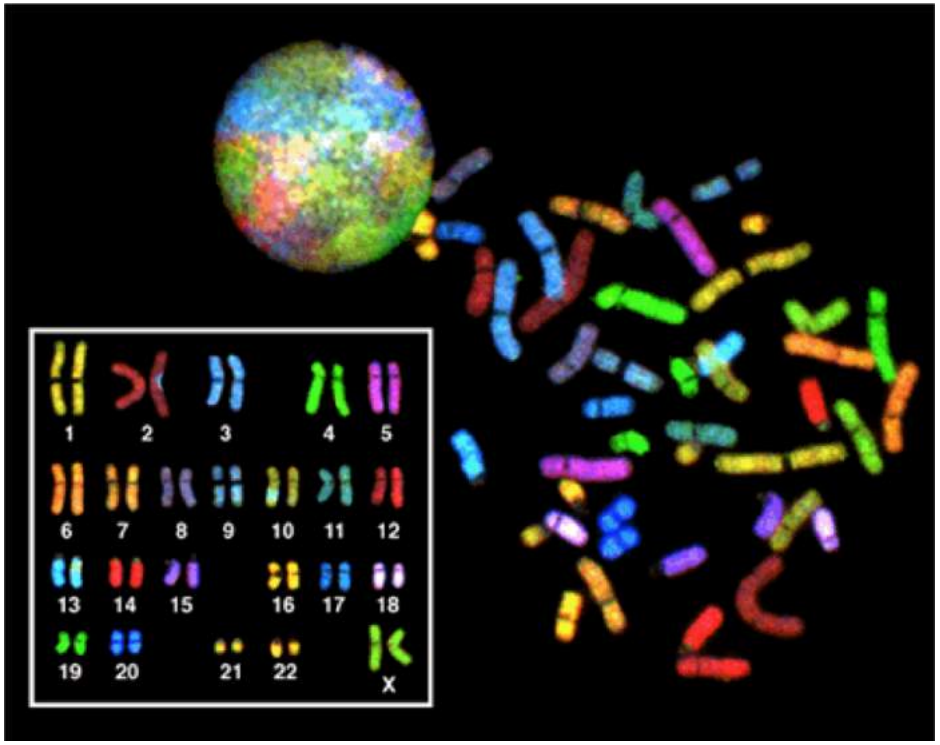


Figure 4–10. Molecular Biology of the Cell, 4th Edition.

What is the Human Genome Project?



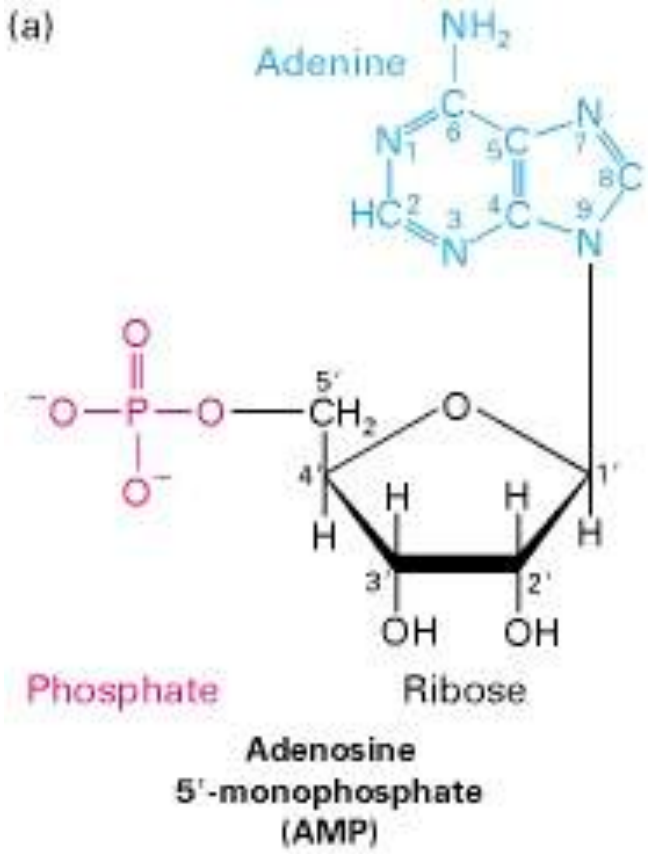


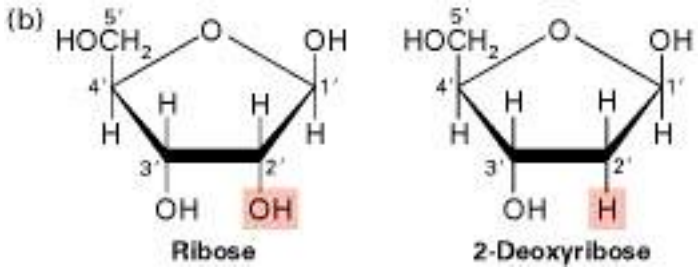
3 billion bases
30,000 genes

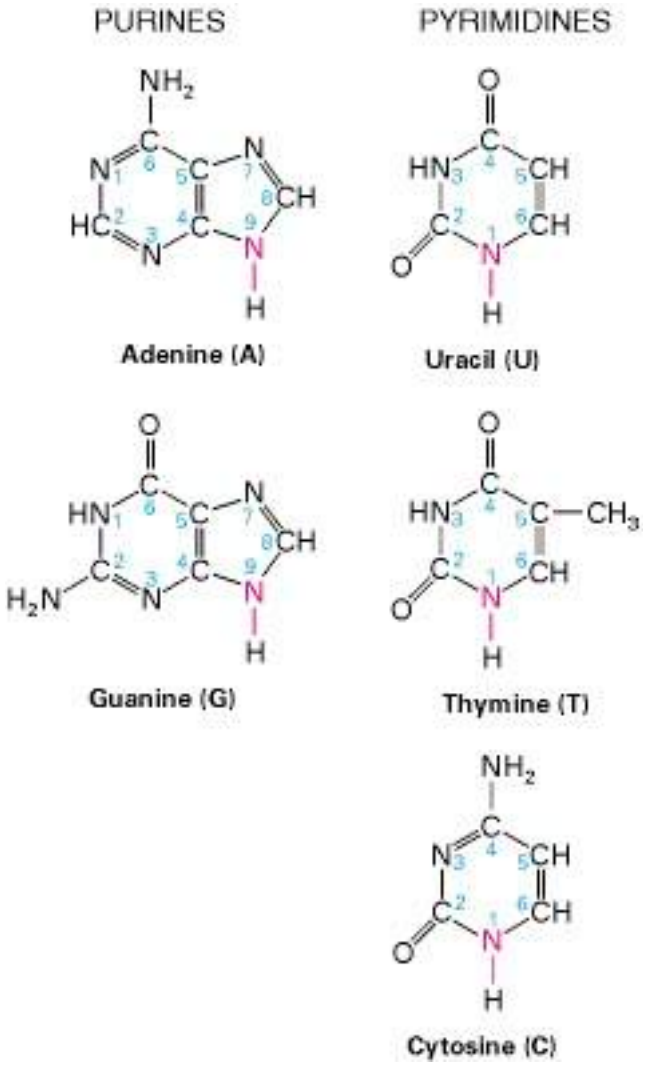
http://www.genome.gov/

- **An organism's genome consists of all its genes.**
- **The Human Genome Project is a multinational research project to determine the sequence of all 3 x 10^9 base pairs and hence all human genes roughly 30000 genes.**

All Nucleotides have a common structure







Three main components of Nucleic acid are:

(1) phosphate (PO4) groups;

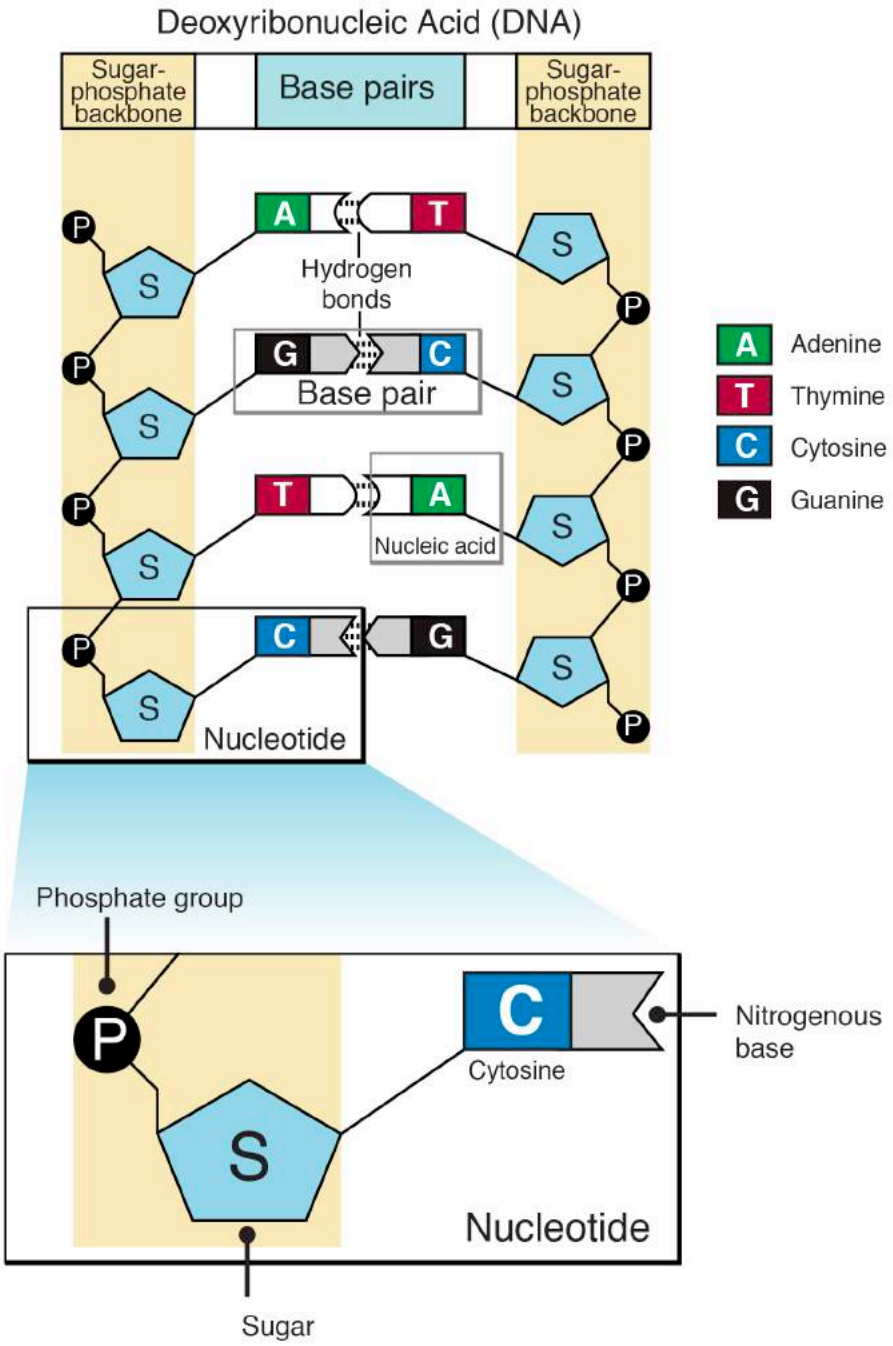
(2) five-carbon sugars; and

(3) nitrogen-containing bases

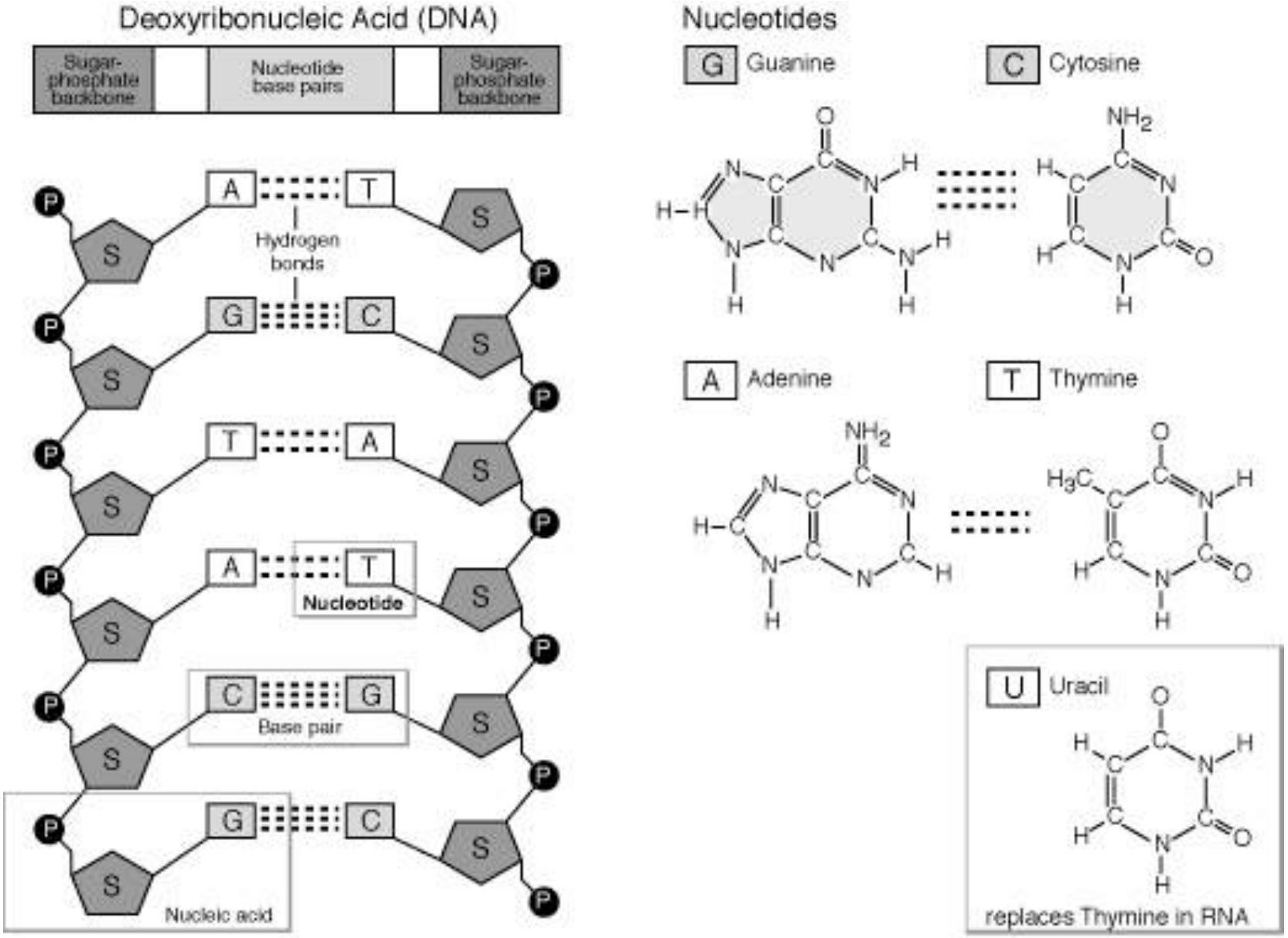
called purines (adenine, A, and guanine G) and pyrimidines (thymine, T, and cytosine, C;
RNA contains uracil, U, instead of T).

From the roughly equal proportions of these components, DNA and RNA molecules are made of repeating units of the three components.

Each unit, consisting of a sugar attached to a phosphate group and a base, is called a nucleotide.



Primary structure of Nucleic Acids



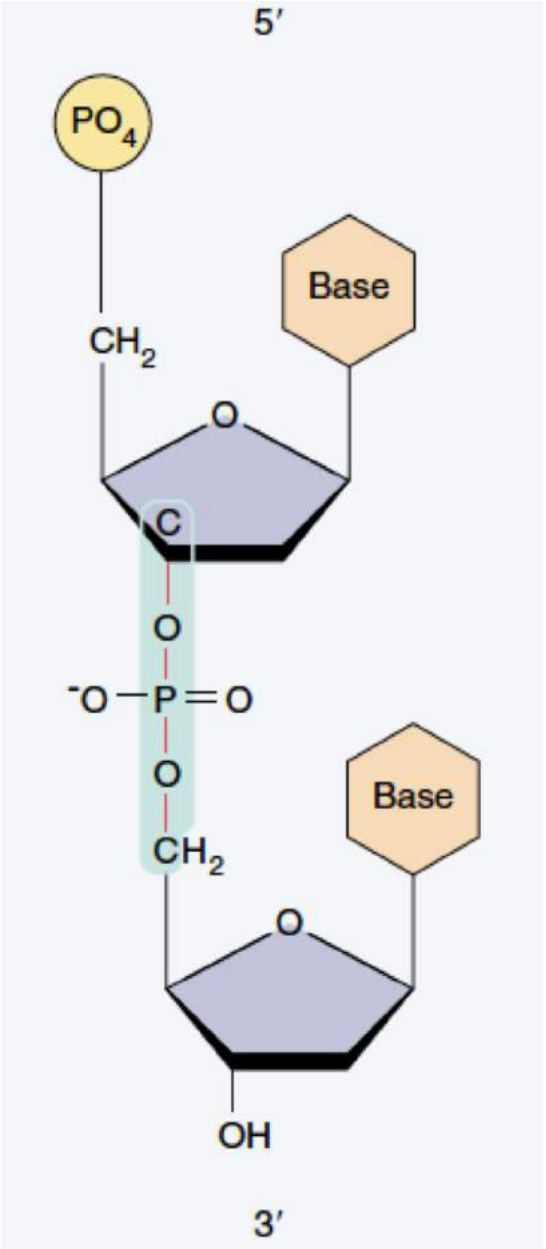
Source: image from the National Human Genome Research Institute (NHGRI)

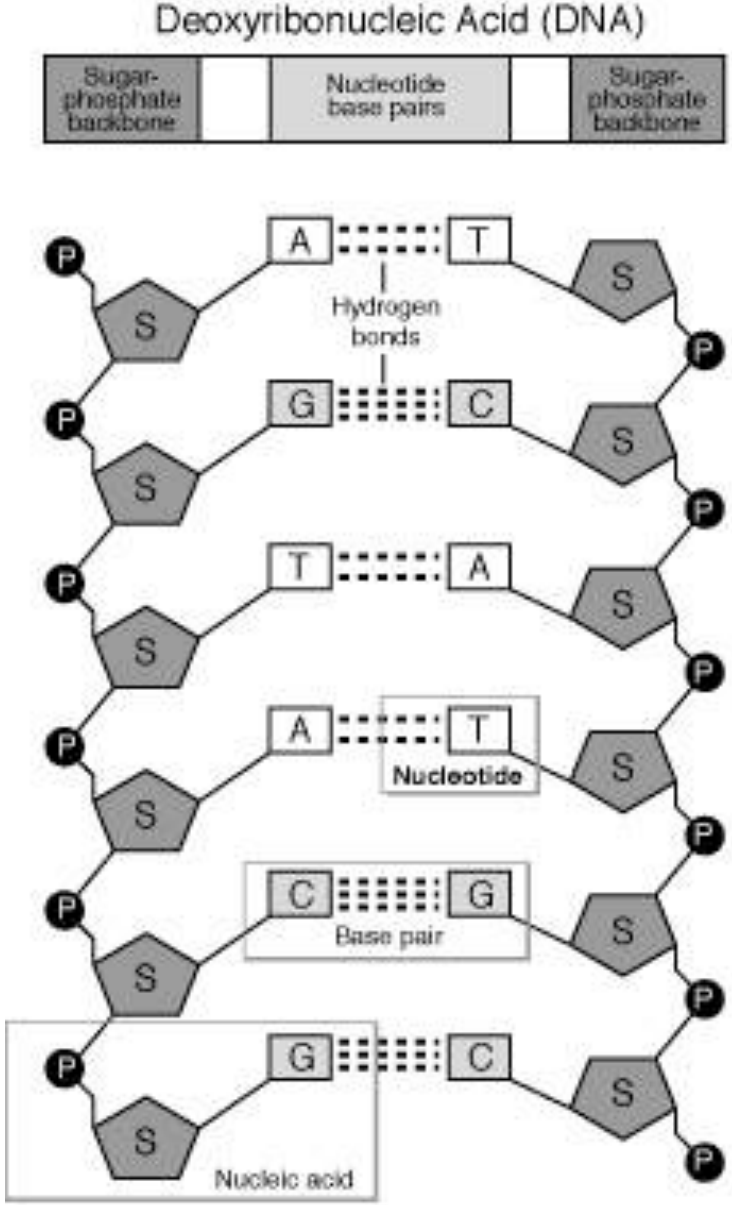
The reaction between the phosphate group of one nucleotide and the hydroxyl group of another is a dehydration synthesis, eliminating a water molecule and forming a covalent bond that links the two groups.

•The linkage is called a phosphodiester bond because the phosphate group is now linked to the two sugars by means of a pair of ester (P—O—C) bonds.

•The two-unit polymer resulting from this reaction still has a free 5′ phosphate group at one end and a free 3′ hydroxyl group at the other, so it can link to other nucleotides.

•In this way, many thousands of nucleotides can join together in long chains.




Deoxyribonucleic Acid (DNA)
Sugar-phosphate backbone
Nucleotide base pairs
Sugar-phosphate backbone
A
T
Hydrogen bonds
G
C
T
A
A
T
Nucleotide
C
G
Base pair
G
C
Nucleic acid
P
S

Erwin Chargaff showed that nucleotide composition of DNA molecules varied in complex ways, depending on the source of the DNA.

Chargaff's Analysis of DNA Nucleotide Base Compositions

Organism	Base Composition (Mole Percent)			
	A	T	G	C
Escherichia coli (K12)	26.0	23.9	24.9	25.2
Mycobacterium tuberculosis	15.1	14.6	34.9	35.4
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Rat	28.6	28.4	21.4	21.5
Human	30.9	29.4	19.9	19.8

Chargaff observed an important regularity in double stranded DNA: the amount of adenine present in DNA always equals the amount of thymine, and the amount of guanine always equals the amount of cytosine.

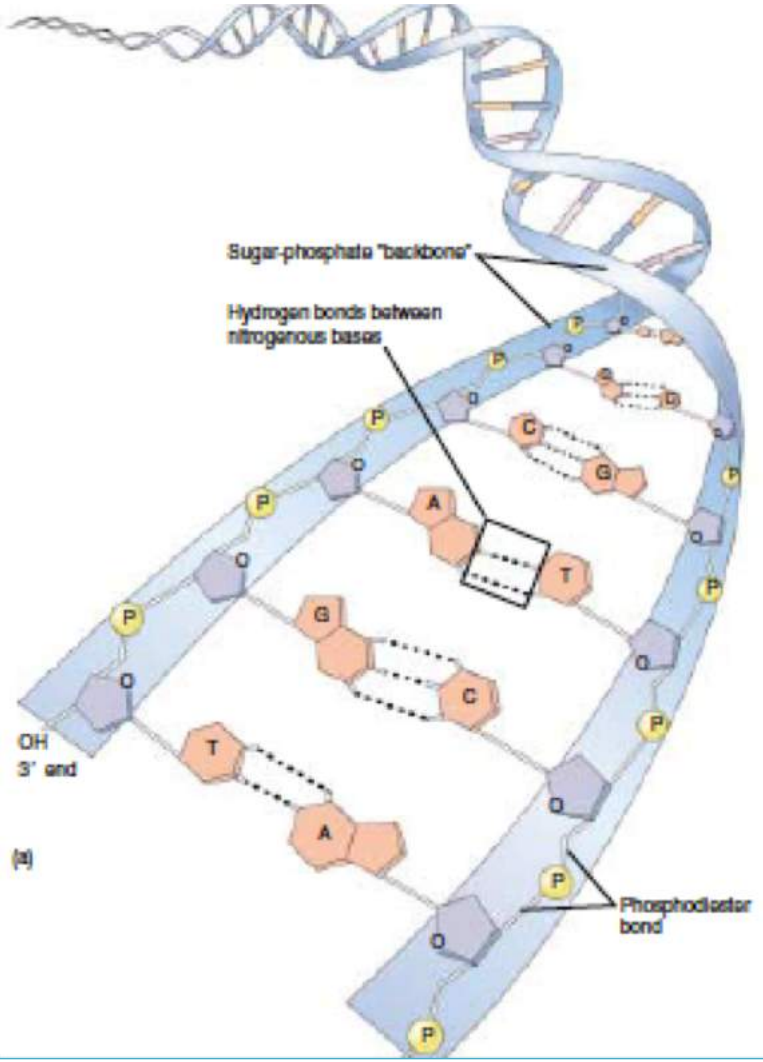
Chargaff's rules:

1. The proportion of A always equals that of T, and the proportion of G always equals that of C: i.e A = T, and G = C.

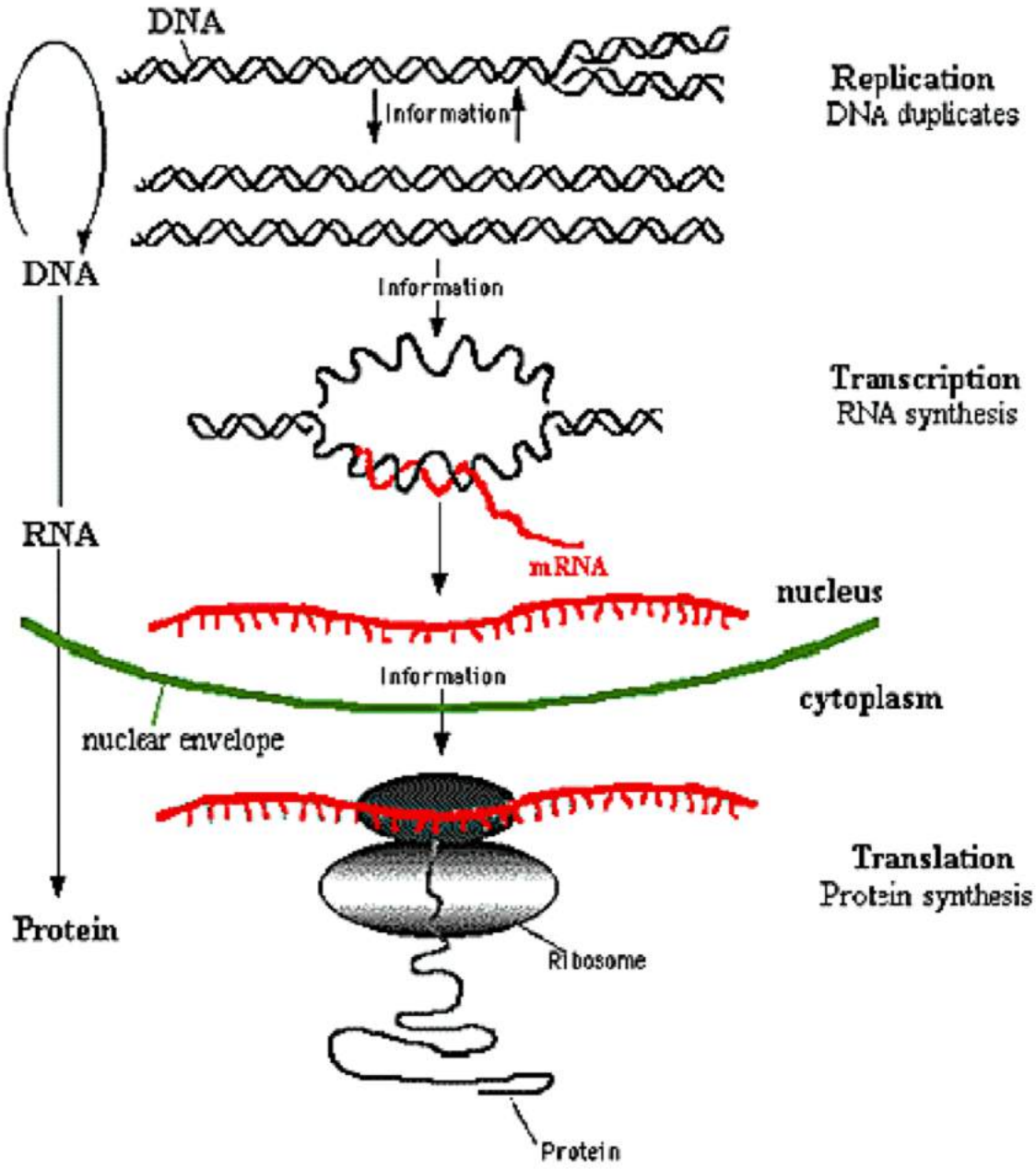
2. It follows that there is always an equal proportion of purines (A and G) and pyrimidines (C and T).

James Watson and Francis Crick, at Cambridge University, worked out structure for the DNA molecule

James Watson and Francis Crick deduced the structure of DNA in 1953 from Chargaff's rules and Franklin's diffraction studies.



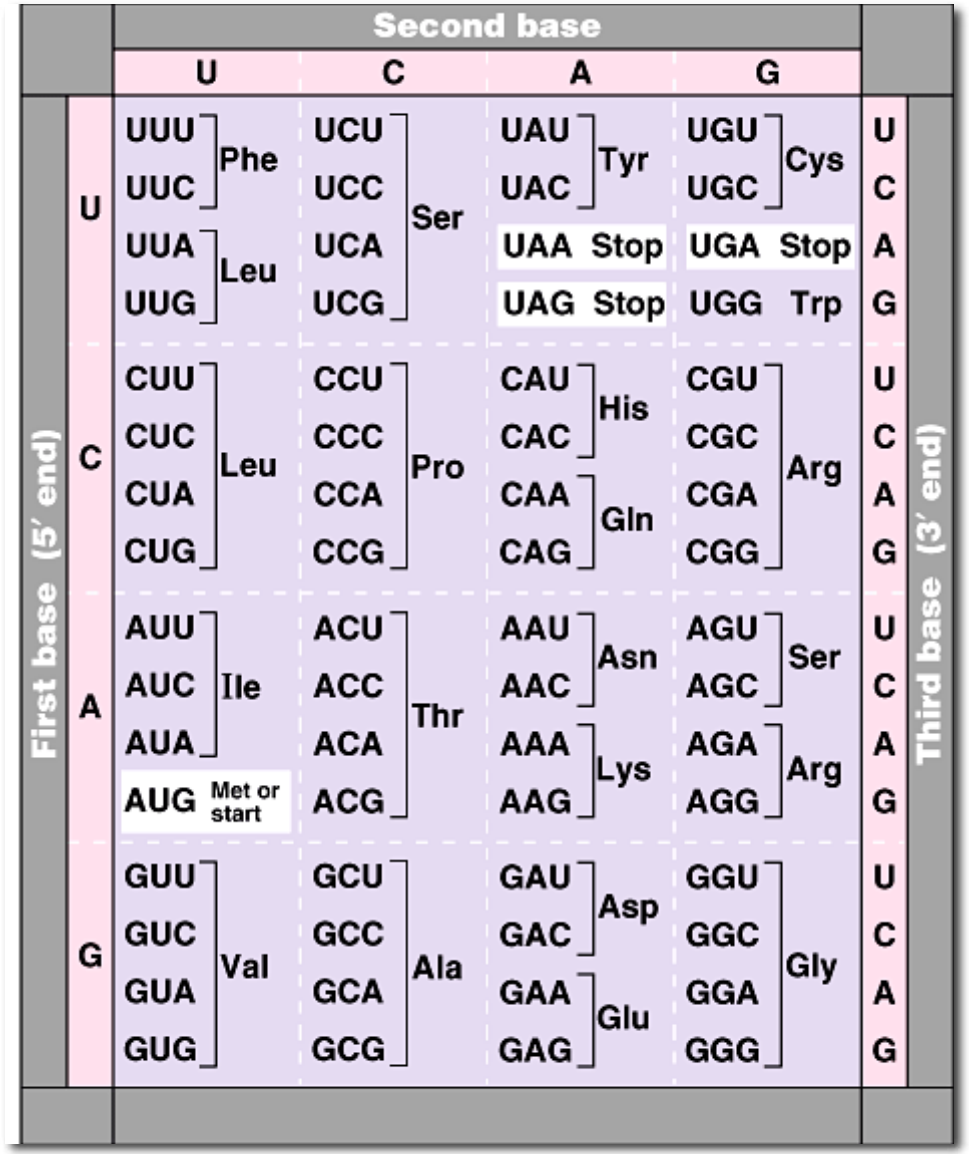
DNA is a double helix. **In a DNA duplex molecule, only two base-pairs are possible: adenine (A) can pair with thymine(T), and guanine (G) can pair with cytosine (C). An A-T base-pair has two hydrogen bonds, while a G-C base-pair has three.**



The Central Dogma of Molecular Biology

The code is universal

- Since all living organisms…
  - use the same DNA
  - use the same code book
  - read their genes the same way



Essentials of Genetics and outcome of genetic engineering

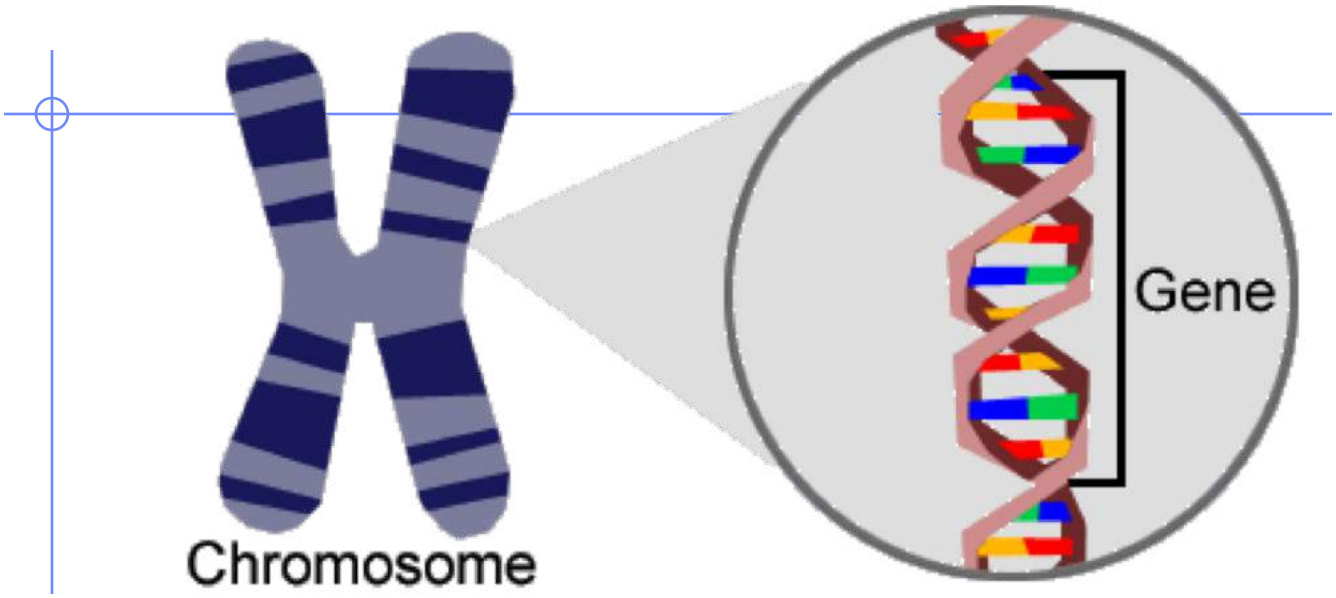
- **Why does a commercial dairy cow produce four times as much milk as most other mammals?**
- **Why do we look like our cousins?**
- **Why do roses come in so many different colors?**

The answers to these and other questions about the diversity of living things involve processes that occur at the level of genes.

Genetics is concerned with genes that are constructed of DNA, the basic building blocks of life.

Genetic engineering is concerned with altering the DNA within particular plants or animals in order to create more healthy or altered products.

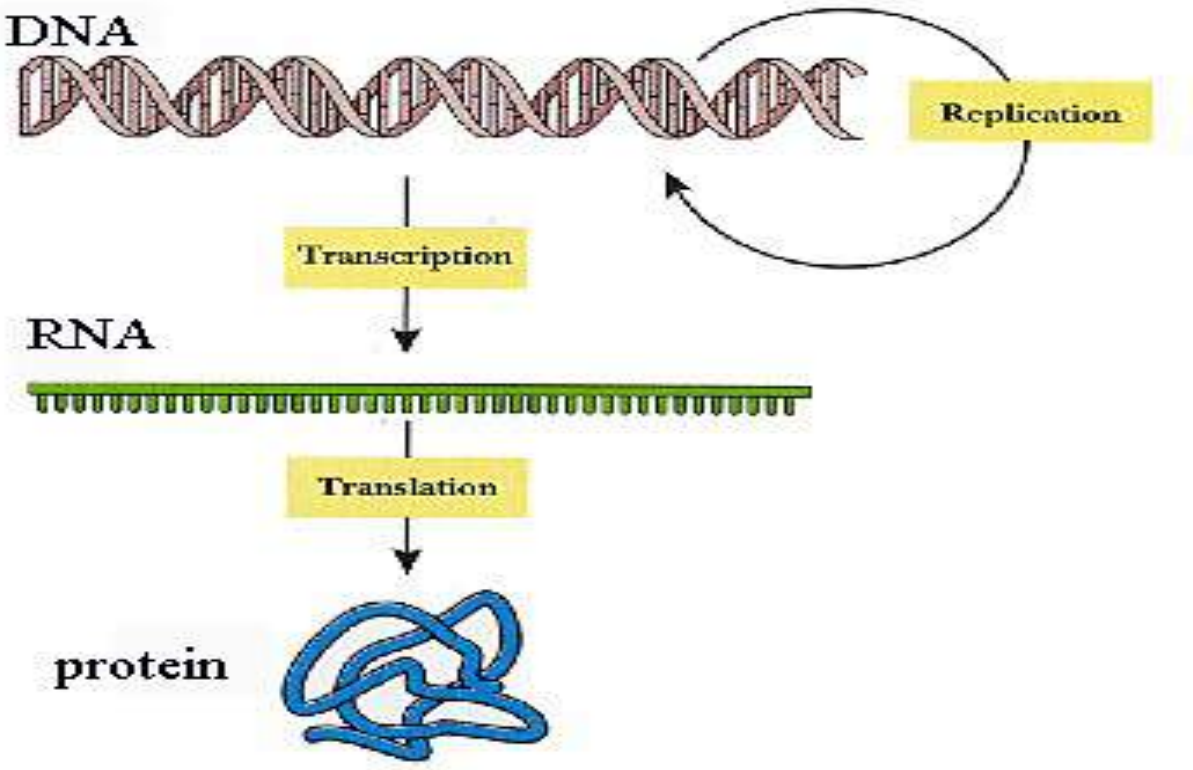
What is a Gene?



A gene is a sequence of DNA on a chromosome that codes for protein.

- The gene is the basic unit of heredity.
- A gene is a stretch of DNA which codes for a specific protein.

Why would altering DNA affect our characteristics/traits?



- DNA codes for the proteins that determine our traits.
- Proteins perform, regulate, or influence all our bodily functions.

What are Genes?

- Genes are at the very heart of life.
- Genes constitute the blueprint of an organism.
- They decide all the properties and all the capabilities of an organism.
- We are defined by our genes and how they interact with the environment.
- In computer terms, genes are the master program of life.
- In biological terms this master program is called the hereditary substance, the chromosomes.
- It is constituted by chains of so called DNA molecules that carry the "code words" or instructions of the master program.

- We are just a vehicle for the reproduction of DNA.

What is genetic engineering?

- **Genetic engineering is deliberate addition, deletion, or intentional mutation of an organism's DNA sequence to produce a desired result.**

- **Genetic engineering means manipulation or alteration of DNA sequences.**

- **Genes, mostly from other, often totally unrelated species are inserted in the genetic "master program".**

- **Genes from e.g. fish, scorpions, bacteria and viruses have been inserted into food plants in genetic engineering projects.**

- **Questions and concerns?**

- **How can apply our understanding of DNA to manipulate specific genes to produce desired traits?**

- **How can we use genetic engineering practice to address current problems facing humanity?**

- **What are moral and ethical problems related to its implementation?**

Genetic engineering is so new and astonishing that people are still trying to figure out the pros and cons. (advantages and disadvantages).

Thank you

Send questions to:

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