Molecular Biology: DNA, gene, chromosome, genome, gene function
(Outline)

Historical perspective (DNA as the genetic material):
• Genetic transformation and DNA
• DNA is the genetic material in bacterial viruses (phage)
• The base-pairing rule
• DNA structure

Nucleic acid structure and composition
• DNA
• Base-pairing rule in DNA
• Definition of DNA, gene, chromosome and genome.
• DNA structure and chemical bonds
• Chromatin and DNA packaging in the nucleus of eukaryotic cells

Gene Function
• RNA structure and types functions
• Flow of information from DNA to protein:
Analogy

Electronic information recognized by Player

Music is produced

Genetic information recognized by Cell machinery

Protein is produced
From a diploid zygote to a multi-cellular organism

Sperm cell

Nuclei containing DNA

Egg cell

Fertilized egg with DNA from both parents

Embryo’s cells with copies of inherited DNA

Offspring with traits inherited from both parents
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850’s</td>
<td>Mendel</td>
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<tr>
<td>1870-1890</td>
<td>Microscopy: Mitosis and Meiosis</td>
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<tr>
<td>1902</td>
<td>Chromosome basis of inheritance (Thomas H. Morgan)</td>
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<tr>
<td>20\textsuperscript{th} century</td>
<td>Work with bacteria and viruses</td>
</tr>
</tbody>
</table>
1928  Fredrick Griffith Experiments
   Concept of transformation (using Bacteria that cause pneumonia in mammals)

1944  Avery, McCarty, and MacLeod
   The transforming material is DNA
   “DNA is the genetic material”

1952  Hershey and Chase
   DNA is the genetic material in viruses that infect bacteria
Griffith- Phenomenon of **Transformation**, a change in genotype (*genetic makeup*) by a foreign substance that changes the phenotype (*observed properties*) of the cell.
• A phage, is a virus that infects bacteria and is made of DNA and protein.

• Alfred Hershey and Martha Chase- the genetic material of the phage T2 is DNA.

[Hershey-Chase Experiment]
DNA is composed of nucleotides

Each nucleotide consists of:

- One phosphate group
- One molecule of the 5-carbon sugar deoxyribose
- One nitrogenous base, either Adenine, Guanine, Cytosine, or Thymine
DNA has four kinds of nitrogenous bases: A, T, C, and G

Thymine (T)  Cytosine (C)  Adenine (A)  Guanine (G)

Pyrimidines  Purines

Figure 10.2B
DNA Structure

Prior to the 1950s, DNA is a polymer of nucleotides consisting of:
- a nitrogenous base
- a sugar
- a phosphate group
Biochemical analysis of DNA:  
Base-pairing rule  

1947  Erwin Chargaff, analysis of DNA from different species %A = %T & %C = %G  

**Human DNA**  
A = 30.9%  
T = 29.4%  
C = 19.9%  
G = 19.8%  

Class TP question
DNA Shape

DNA is a double-stranded helix

James Watson and Francis Crick worked out the three-dimensional structure of DNA, based on work by Rosalind Franklin

Figure 10.3A, B
The structure of DNA

- two polynucleotide strands wrapped around each other in a double helix
Each DNA strand of the double helix is oriented in the opposite direction.
– Covalent bonds hold the sugar phosphate backbone
– Hydrogen bonds between bases hold the two strands
– Each base pairs with a complementary partner
  A with T, and G with C
From DNA to Genome

• Gene: a linear stretch of nucleotides with information for one product (mostly polypeptide or protein)

• Chromosome: a very long stretch of DNA carrying many genes. DNA is always associated with protein as chromatin

• Genome: totality of DNA in a cell
The DNA of the gene is transcribed into RNA which is translated into the polypeptide (protein).
Transcription is RNA synthesis

Transcription uses DNA as a template to produce RNA.

The nucleotide sequence of the DNA determines the nucleotide sequence of the RNA that is transcribed.

RNA sequence is complementary to the DNA.
Translation is protein synthesis

Translation takes place at ribosomes.

Three types of RNA interact with each other to carry out translation:

- **Messenger RNA** (mRNA) brings the information.
- **Ribosomal RNA** (rRNA) makes up the ribosome.
- **Transfer RNA** (tRNA) brings the amino acids.
RNA nucleotides pair with DNA nucleotides

To make RNA, base pairing takes place between RNA and DNA.

- Adenine (A) – Uracil (U)
- Cytosine (C) – Guanine (G)
- Guanine (G) – Cytosine (C)
- Thymine (T) – Adenine (A)
Compare and contrast DNA with RNA

a. Structure

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<thead>
<tr>
<th>Sugar</th>
<th>DNA</th>
<th>RNA</th>
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<tbody>
<tr>
<td>Deoxyribose</td>
<td>![DNA sugar]</td>
<td>![RNA sugar]</td>
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<table>
<thead>
<tr>
<th>Nucleotide bases</th>
<th>DNA</th>
<th>RNA</th>
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<tbody>
<tr>
<td>Adenine (A)</td>
<td>![Adenine DNA]</td>
<td>![Adenine RNA]</td>
</tr>
<tr>
<td>Cytosine (C)</td>
<td>![Cytosine DNA]</td>
<td>![Cytosine RNA]</td>
</tr>
<tr>
<td>Guanine (G)</td>
<td>![Guanine DNA]</td>
<td>![Guanine RNA]</td>
</tr>
<tr>
<td>Thymine (T)</td>
<td>![Thymine DNA]</td>
<td>![Uracil RNA]</td>
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<table>
<thead>
<tr>
<th>Form</th>
<th>DNA</th>
<th>RNA</th>
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<tbody>
<tr>
<td>Double-stranded</td>
<td>![DNA double-stranded]</td>
<td>![RNA single-stranded]</td>
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<table>
<thead>
<tr>
<th>Functions</th>
<th>DNA</th>
<th>RNA</th>
</tr>
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<tr>
<td>Stores RNA- and protein-encoding information; transfers information to next generation of cells</td>
<td>![DNA functions]</td>
<td>Carries protein-encoding information; helps to make proteins; catalyzes some reactions</td>
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b. Complementary base pairs

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