Unit 5  From DNA → Genetic Engineering

• Structure and function of DNA & RNA
• Replication
• Transcription and translation
• Genetic mutations
• Biotechnology
What is the relationship between chromosomes, nucleus, histones, DNA, genes?

pp280
DNA - What is DNA, what is it made up of & why is it important? Pp 345

What-DNA = De-oxy-ribo-nucleic Acid

• Shape = double helix
• Sides = 5Csugar, phosphate joined by covalent bond
• Rung or steps = bases pairs/name bases
  - Adenine + thymine – A pairs w. T
  - Guanannine + cytosine - G pairs w. C
• Bases are connected w. hydrogen bond
• Nucleotide = dexo-ribose sugar + phosphate + Base
• Pp343 - DNA’s Importance - Proteins, enzymes, inheritance, heredity, genes, common ancestor, storing copying .information

*Chargoff’s Rule says
% of A = % of T and % of C = % of G pp345
SCIENTISTS

• Scientists related to the History or science of DNA
• PP349 Examine Pic.
• Know who was responsible or what
What is RNA, why is important & how does it differ from DNA?

1. **DNA** = deoxyribonucleic Acid
   
   **RNA** = Ribonucleic acid

2. DNA - has a deoxyribose sugar
   RNA has a ribose sugar

3. DNA has a double helix shape
   RNA has a single strand

4. DNA has bases A+T and C+G
   RNA has bases A+U (uracil) and C+G

**Importance**
Making of Amino Acids → proteins

**Types of RNA**
- mRNA = messenger
- tRNA = transfer RNA
- rRNA = ribosomal RNA
### EQ1: Steps in Replication Process

<table>
<thead>
<tr>
<th>In S phase of Interphase of Cell Cycle where DNA replicates</th>
<th>Enzyme----ase</th>
<th>What happens.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Unzipping of DNA molecule</td>
<td>Helicase</td>
<td>pp351Bks DNA separates, H2 bonds break, bases exposed.</td>
</tr>
</tbody>
</table>
| B. Nucleotides with bases are added. This happens continuously in the leading strand.. in 5C→3C direction | DNA Polymerase | 1. Bases added  
2. Proofreads each new DNA strand |
| C. DNA fragments or pieces made in lagging strand are joined become one. | DNA ligase | Fragments are joined together as one |
| D. In slow replicating parts of the cell 352               | Telomerase    | Speeds up copying. Protects cells from damage. |

### EQ2: How is replication in Prokaryotes different from eukaryotes 353

| Prokaryotes 353 | PP353 NEW Pro-Replication starts from 1 single point  
Euk-Replication starts from many points |
The Processes re DNA

1. DNA Replication - 350 Red

FROM DNA TO PROTEINS:

i. RNA Transcription - pp364 Video - Process + Intron + Exons

ii. + Translation video - 368

* Know what we start with.
* What we end with.
* Where the process occurs.
* Players + steps involved.
* Importance of process.

READ 370
The flow of information from DNA to RNA to proteins is one of the fundamental principles of molecular biology. It is so important that it is sometimes called the “central dogma. Through the processes of transcription and translation, information from genes is used to make proteins.
What are mutations + what are the different types of mutations?

How is a sex cell mutation different from a body cell mutation?

- Mutations in Genes

* Mutations in Chromosomes

- Substitution
- Frameshift

Human Mutations
- Sickle Cell Anemia-hemoglobin 374
- Cystis Fibrosis-CF-deletion 398

How is a mutation in a sex cell/gamete/sperm/egg different from a mutation in a body or somatic cell like a nerve, skin, brain or any other cell?

* In sex cell mutation DOES PASS to offspring
* In a somatic/body cell mutation DOES NOT PASS to offspring
What are Mutagens - physical + chemical substances that may be in foods or environment and can → mutations

Harmful Mutations-
* e.g. Cancer - a mutation causes cell not to pick up signals to stop dividing, continuing division → overproduction of cells
* Cystic fibrosis - Deletion of gene = gene mutation
* Downs syndrome - nondisjunction/triploidy = chromosomal mutation
* Sickle cell - mutation in hemoglobin protein

Beneficial Mutations-
- e.g. New proteins;
- Resistance to disease in plants;
- Resistance to pesticides in plants;
- New species with adaptations
1. EQ: What is Genetic Engineering, recombinant DNA & transgenic organisms.

2. How do restriction enzymes work and why are Restriction enzymes important?
   Examples of restriction enzymes = Endonucleases pp424- Slide 12

3. What are vectors/plasmid and why are they required after restriction enzymes cut DNA?
   pp424 Slide 12

4. Polymerase Chain Reaction - DNA is multiplied artificially as opposed to bacterial transformation + cloning PP 523

5. Sequencing DNA

6. Bacterial Transformation pp425

7. Gel Electroporesis Slide 13

8. Examples of uses of GE -
   **Genetically engineered Bacteria used to make insulin for diabetic humans and blood clotting substances for hemophilia**
BACTERIAL TRANSFORMATION 524-525

Restriction enzymes /Recombinant DNA/Plasmid

1. Restriction enzyme cuts the sugar-phosphate backbones at each arrow.

2. DNA fragment from another source is added. Base pairing of sticky ends produces various combinations.

3. DNA ligase seals the strands.
 WHICH SUSPECT MATCHES THE DNA OF THE CRIME SCENE?

* Smaller DNA fragments move faster.
* DNA fragments are negative and move towards the positive pole
* Because the fragments are cut into different lengths by restriction enzymes we use the term **Restriction Fragment Length Polymorphism**.
Ethical Issues/concerns about using Genetic Engineering

- *Confidentiality and Patents over using DNA
- *Safety of (GMO’s) genetically modified organisms as in foods like vegetables and animals.
- *Concerns about whether the effects of GE on agriculture can be beneficial or harmful.
- *Some people have religious concerns as they believe GE is humans playing God.
UNIT 5 VOCABULARY – TOPIC DNA and RNA


5.3 - mutation, frameshift-mutation, point-mutation, gene-mutation, chromosomal-mutation, substitution, gamete, mutagen, somatic cell, polyploidy, triploidy, karotype, genome, sex-chromosomes, autosomes, non-disjunction (Downs syndrome)

5.4- genetic-engineering, GMO (genetically modified organism), plasmid, vector, restriction – enzyme, recombinant-DNA, transgenic- organism, transformation,
UNIT 5-Learning Objectives-Students will be able to...
5-1: Describe the contributions of different scientists to the discovery of DNA structure and function. (SC.912.L.16.9, SC.912.L.18.1, SC.912.N.2)
5-2: Analyze the structure and function of DNA. (SC.912.L.16.3, SC.912.L.18.1)
5-3: Identify DNA as the universal genetic molecule for all living things. (SC.912.L.16.9)
5-4: Develop a model of a DNA molecule. (SC.912.L.16.9, SC.912.L.18.1, SC.912.N.3.5)
5-5: Explain the relationship among genes, chromosomes, and DNA. (SC.912.L.16.9)
5-6: Describe the process of DNA replication. (SC.912.L.16.3)
5-7: Identify the role of enzymes in DNA replication. (SC.912.L.16.3, SC.912.L.18.11)
5-8: Relate the structure of DNA to its ability to replicate itself accurately. (SC.912.L.16.3)
5-9: Analyze how DNA controls the activity of the cell through the production of proteins. (SC.912.L.16.5, SC.912.L.18.1)
5-10: Explain that proteins are the result of gene expression. (SC.912.L.16.5)
5-11: Analyze the structure and function of RNA. (SC.912.L.16.5, SC.912.L.18.1)
5-12: Summarize how the process of transcription results in the formation of mRNA from DNA. (SC.912.L.16.5)
5-13: Explain how the mRNA code is translated into an amino acid sequence during protein synthesis. (SC.912.L.16.5)
5-14: Model the processes of transcription and translation that result in protein production. (SC.912.L.16.5, SC.912.N.3.5)
5-15: Explain the evolutionary significance of a universal genetic code. (SC.912.L.16.9)
5-16: Explain how mutations in DNA may or may not result in changes in organisms. (SC.912.L.14.6, SC.912.L.16.4)
5-17: Differentiate between mutations in somatic cells and gametes. (SC.912.L.14.6, SC.912.L.16.4, SC.912.L.16.8)
5-18: Describe the different types of mutations (e.g., gene mutations, chromosomal mutations) in DNA. (SC.912.L.16.4, SC.912.N.1.6)
5-19: Analyze how genetic mutations can affect protein production. (SC.912.L.16.4)
5-20: Describe how mutation in DNA can increase genetic variation in a species by introducing new characteristics. (SC.912.L.15.15)
5-21: Identify various causes of mutations in DNA (e.g., mutagens, replication mistakes). (SC.912.L.14.6, SC.912.L.16.8, SC.912.N.4.1)
5-23: Explain that transgenic organisms contain recombinant DNA from other organisms. (SC.912.L.16.12^)
5-24: Describe how restriction enzymes and bacterial transformation are used in the construction of recombinant DNA. (SC.912.L.16.7^, SC.912.L.16.12^)
5-26: Compare the economic, ethical, environmental, and societal benefits and costs of genetic technologies. (SC.912.L.16.10, SC.912.N.4.2)
5-27: Evaluate the impact of biotechnology on the individual, society, and the environment. (SC.912.L.16.10, SC.912.N.4.1)
1. A segment of a DNA strand has the following bases: TAC GAT. What is the complementary strand of DNA?  
A. UAG CAU  
B. TAG CAT  
C. ATG CTA  
D. AUG CUA

2. In DNA, adenine pairs up with thymine and guanine with cytosine. If adenine makes up 40% of the bases in DNA, then what percentage of the bases in DNA does cytosine make up?  
A. 10%  
B. 20%  
C. 40%  
D. 50%

3. A DNA strand with the sequence AACGTAACG is transcribed. What is the sequence of the mRNA molecule synthesized?  
A) AACGTAACG  
B) UUGCAUUGC  
C) AACGUAACG  
D) TTGCATTGC

4. Transcription and translation of a gene composed of 30 nucleotides would form a protein containing no more than ____ amino acids. (Hint – how many nucleotides/bases in an amino acid)  
A) 10  
B) 15  
C) 60  
D) 90.

5. RNA contains which bases?  
A) adenine, thymine, guanine, cytosine, uracil  
B) adenine, thymine, guanine, cytosine  
C) thymine, guanine, cytosine, uracil  
D) adenine, guanine, cytosine, uracil

6. The transcribing enzyme is  
A. Ligase.  
B) DNA polymerase.  
C) RNA polymerase.  
D) amino-acyl transferase.

7. Transfer RNA's bind during translation by the  
A) codon.  
B) anticodon.  
C) template  
D. protein

8. Which molecule contains the genetic code?  
A) DNA  
B) mRNA  
C) tRNA  
D) rRNA
9. The process of copying a gene's DNA sequence into a sequence of RNA is called
   A) replication. B) transcription. C) translation. D) PCR

10. Each organism has a unique combination of characteristics encoded in molecules of
    A. protein. B. carbohydrates. C. enzymes. D. DNA.

11. The primary function of DNA is to pp343

12. Watson and Crick built models that demonstrated that pp349
    A. DNA and RNA have the same structure. B. DNA is made of two chains in a double helix. C. guanine forms hydrogen bonds with adenine. D. thymine forms hydrogen bonds with cytosine.

13. The base-pairing rules state that the following are base pairs in DNA: pp345

14. The addition of nucleotides(base) to form a complementary strand of DNA 350-351
    A. is catalyzed by DNA polymerase. B. is accomplished only in the presence of tRNA. C. prevents separation of complementary strands of RNA. D. is the responsibility of the complementary DNA

15. During DNA replication, a complementary strand of DNA is made for each original DNA strand. Thus, if a portion of the original strand is CCTAGCT, then the new strand will be pp350-351
    A. TTGCATG. B. CCTAGCT. C. AAGTATC. D. GGATCGA.
16. Which of the following is not true about DNA replication? pp350-351
A. It must occur before a cell can divide.                 D. The process is catalyzed by enzymes called DNA mutagens.
C. The double strand unwinds while it is being duplicate   B. Two complementary strands are duplicated.

17. The enzymes responsible for adding nucleotides to the exposed DNA template bases are pp350-351

18. The function of tRNA is to –pp368-369
A. synthesize DNA.       B. synthesize mRNA.       C. form ribosomes.       D. transfer amino acids to ribosomes.

19. Which of the following types of RNA carries instructions for making proteins? pp363
A. mRNA             B. tRNA             C. rRNA             D. All of the above

20. RNA differs from DNA in that RNA pp362
A. is sometimes single-stranded.       B. contains a different sugar molecule.
    C. contains the nitrogenous base uracil.       D. All of the above

21. Which of the following would represent the strand of DNA from which the mRNA strand mRNA: CUCAAGUGCUUC was made? 364
a. CUCAAGUGCUUC  b. GAGUUCACGAAG  c. GAGTTCACGAAG  d. AGACCTGTAGGA
22. mRNA = CUCAAGUGCUUC. The anticodons for the codons in the mRNA in the strand are 368-369
A. GAG—UUC—ACG—AAG.  
B. GAG—TTC—ACG—AAG.  
D. CUC—GAA—CGU—CUU.  
D. CUU—CGU—GAA—CUC.

23. In order for protein synthesis to occur, mRNA must migrate to the Slide #8
A. ribosomes.  
B. RNA polymerase.  
C. lac operon.  
D. heterochromatin.

24. Each nucleotide triplet in mRNA that specifies a particular amino acid is called a(n) 368-369
A. mutagen.  
B. anticodon.  
C. codon.  
D. exon.

25. An error in DNA replication can cause pp372
A. mutations.  
B. genetic variation.  
C. cancer.  
D. All of the above

26. Genes contain instructions for assembling
A. purines.  
B. nucleosomes.  
C. proteins.  
D. pyrimidines.

27. DNA replication results in two DNA molecules, 350-351
A. each with two new strands.  
B. one with two new strands and the other with two original strands.  
C. each with one new strand and one original strand.  
D. each with two original strands.

28. What happens during the process of translation? 368-369
A. Messenger RNA is made from DNA  
B. The cell uses information from messenger RNA to produce proteins  
C. Transfer RNA is made from messenger RNA.  
D. Copies of DNA molecules are made.
29. The bases of one strand of DNA match-up with the bases of the second strand according to base pairing rules, therefore, the two strands are said to be **pp350-351**

A. oppositely charged  
B. complementary  
C. identical  
D. diagonal

30. A mutagen is **372**

A) a chemical or physical agent that induces mutations  
B) an enzyme that repairs mutations  
C) a molecule which stabilizes DNA thus prevents mutations from occurring

31. How many codons are needed to specify three amino acids (honors)?

A. 3  
B. 6  
C. 9  
D. 12

32. The enzyme used in the polymerase chain reaction is--- **pp423**

A.) restriction endonuclease.  
B) reverse transcriptase.  
C) DNA polymerase.  
D) RNA polymerase

33. A method used to distinguish DNA of one individual from another is **Slide13**

polymerase chain reaction.  
B) cDNA.  
C) reverse transcriptase.  
D) restriction fragment length polymorphism

34. Which of the following is an example of a genetically engineered organism? **428**

A. Seedless fruits resulting from grafting of one plant onto another  
B. A plant that naturally possesses medicinal properties  
C. A new plant variety created by cross-pollination  
D. A plant that received external DNA to produce natural insecticides
35. All fragments cut by most restriction endonucleases have \textit{pp.424.digram}
\begin{enumerate}
\item A) complementary double-stranded ends
\item B) supplementary single-stranded ends
\item C) double-stranded "sticky" ends
\item D) complementary single-stranded ends
\item E) double-stranded supplementary ends
\end{enumerate}

36. \textbf{Bacteria are the "workhorses" of genetic engineering because they ________.} \textit{pp424}
\begin{enumerate}
\item A. Reproduce very slowly and accurately
\item B. can readily take up plasmids containing human genes and then produce the human proteins encoded by those genes
\item C. are always homozygous
\item D. they provide the polymerase for the polymerase chain reaction
\end{enumerate}

37. Samples of DNA that were cut with a restriction enzyme during DNA fingerprinting in a crime lab utilizes a technique to produce the bands of DNA is called \textit{Slide 13}
\begin{enumerate}
\item A. gene splicing
\item B. gel-electrophoresis
\item C. genetic engineering
\item D. cloning
\end{enumerate}

38. Gel electrophoresis separates DNA fragments according to their ________.
\begin{enumerate}
\item A. base sequence
\item B. size
\item C. electrical charge
\item D. percentage of labeled nucleotides
\end{enumerate}

39. \textbf{Which is a use of genetically engineered bacteria?} \textit{Slide 11}
\begin{enumerate}
\item A. identifying the remains of an unknown person
\item B. developing a DNA fingerprint for blood left at a crime scene
\item C. making human insulin for diabetics
\item D. producing corn that is resistant to herbicides
\end{enumerate}

40. Which enzymes are used to cut large segments of DNA into fragments for DNA fingerprinting? \textit{424}
\begin{enumerate}
\item A. DNA ligase
\item B. DNA polymerase
\item C. reverse transcriptase
\item D. restriction enzymes