UNIT SIX: DNA, THE HEREDITARY MATERIAL; PROTEIN SYNTHESIS

Upon completion of this unit you will be able to:

1. List several characteristics which the genetic material must possess.
2. List the components of a nucleotide.
3. Name and describe the five different nitrogenous bases.
4. Explain how DNA molecules vary in structure from one species to another; thus producing variations in the proteins of different species.
5. Describe the bonding between the nitrogenous bases in the DNA molecule.
6. Diagram the process of DNA replication if given a "sense" strand of DNA.
7. Provide the functions of endonuclease, exonuclease, polymerase and ligase.
8. Identify the different types of RNA.
9. Diagram the process of DNA transcription if given a "sense" strand of DNA.
10. Diagram the process of translation (protein synthesis).
11. Compare and contrast DNA and RNA.
12. Describe how DNA controls the synthesis of proteins in a cell.
13. Differentiate between frameshift and point mutations.
14. List several causes of mutations and how they might effect DNA.
15. Distinguish between somatic and sex cells.
16. Explain how cancer is caused and treated.
17. Relate the operon concept to the regulation of gene activity and the functioning of a living organism.
18. Define and discuss differentiation.
19. Discuss bacterial plasmids and processes involved in recombinant DNA procedures.
20. List the importance of **transduction** and transformation in bacteria.
21. Define locus, gene and chromosome.
22. Describe the chromosome theory.
23. Differentiate between haploid and diploid cells.

Unit References: Text Chapter 3 pgs. 58-61; Text Chapter 8
www.mhhe.com/enger13
An Online Biology Text Book

DNA From The Beginning
PBS - DNA Workshop
Genetics Education Center

Unit 6: DNA The Hereditary Material/ Protein Synthesis

DNA- DeoxyriboNucleic Acid; reference library of "How-To" books

Search for Genetic Material

A. Requirements for genetic material: (Objective #1)

1. Must be able to store info used to control development and metabolic activities.

2. Must be stable so that it can be replicated w/ high fidelity and passed generation

to generation

3. Must be able to undergo mutation to generate variability (changes must be inheritable)

4. Must be chemically diverse

5. Must use stored info to direct synthesis of products necessary for operation of cell.

B. **Early researchers believed protein was genetic material because of its diversity.**

1. Meischer- nuclein

2. Griffiths (1928) bacterial transformation, material passed

3. Avery and others- chemical proof that Griffiths found DNA not protein

4. Hershey and Chase (1952)- used virus and radioactive isotopes of sulfur and phosphorous, Concluded: DNA genetic material

5. Watson/Crick/Franklin (1953)- structure of DNA, double helix w/ 4 nitrogenous bases of differing sequences.

II. Structure of DNA (Objectives #2, 3) Text pg. 58-61, 152-155

Check Out **:**

DNA Structure Tutorial
What Is A Genome?

Google- DNA

DNA Anatomy

Intro To DNA Structure

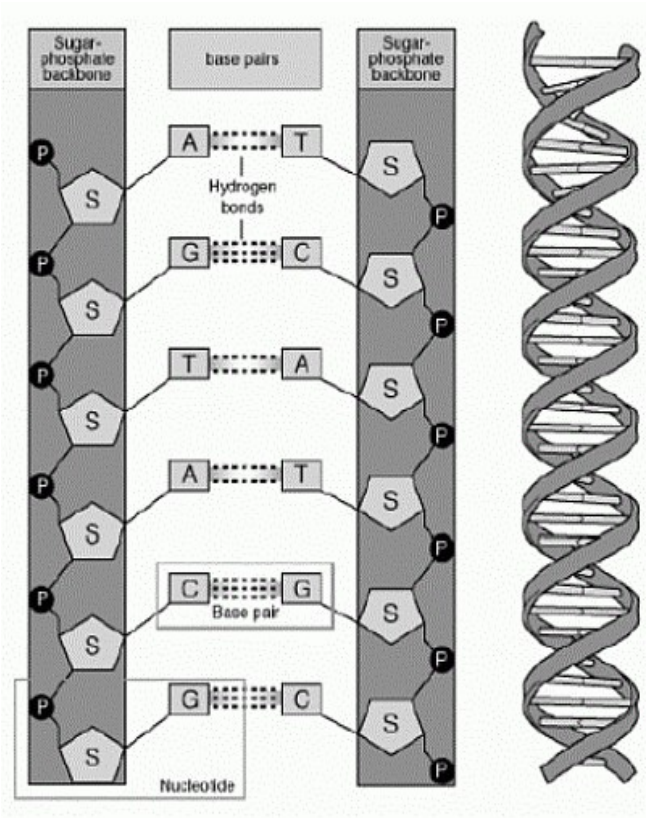
DNA- deoxyribonucleic acid

1. **Double Helix** (zipper, ladder, spiral staircase)
2. Helix consists of 2 **complementary** chains of nucleotides
3. **Nucleotide** = 1 nitrogenous base + 1 deoxyribose sugar + 1 phosphate

4. Nitrogenous bases:

PURINES	**PYRIMIDINES**
Adenine (**A**)	Thymine (**T**)
Guanine (**G**)	Cytosine (**C**)

DOUBLE STRANDED HELIX (Objective #5) Text pg 153



S- deoxyribose sugar

P- phosphate

RNA- RiboNucleic Acid **Text pg. 61, 155**

1. uses ribose sugar rather than deoxyribose
2. single stranded (health issues)
3. Bases A, C, G, and U (uracil, substitutes for thymine)

Chargaff's Rules- Complementary Base Pairing (Objective #4, 5)

1. Base composition of DNA differs from species to species

a. amount of DNA
b. sequences of bases on DNA

2. In each species, however, the %A = %T and %C = %G

-further, 50% of bases purines (A & G) and 50% of bases pyrimidines (T & C)
-therefore, A must pair w/ T; C must pair w/G

DNA Replication - mitosis (cell division) (Objective #6) text pgs. 153-154

-**Watson/Crick** model suggests replication by Complementary Base Pairing
-during replication each parental DNA strand serves as a template ("blueprint") for a new strand
-replication requires the following steps:

1. DNA must unwind (helicase) and "unzip" (break hydrogen bonds)

2. Complementary nucleotides, always present in nucleus, move into place by complementary base pairing

3. Nucleotides joined to reestablish double strand: Steps #2, #3 carried out by DNA Polymerase

4. When done, 2 completed, identical, double stranded DNA molecules present

Check Out:

Google- DNA Replication

YouTube- DNA Replication

DNA Replication

DNA Replication is Semiconservative- each new double helix contains one parental strand and one new strand; Meselson and Stahl 1958- radioactive isotope N^{15}

Enzyme Activity (Objective #7)

1. **Polymerase**- enzyme responsible for addition of nitrogenous bases (nucleotides) to newly forming strands of DNA
   a. Has proofreading function that checks each pairing.

2. **Exonuclease**- can remove nucleotide from end of chain

3. **Endonuclease**- break bonds within chain (restriction enzymes)
4. **Ligase**- repairs nicks and cuts within chain

Accuracy of Duplication

-estimated mistakes 1/10,000 base pairs
-actual 1/1,000,000,000
much better than estimated due to action of polymerase proofreading
-if error does occur and is not corrected, then a gene mutation has occurred.

II. PROTEIN SYNTHESIS- (Objective #9, 10, 12) Text pgs. 155-162
-gene expression, cell activity; DNA master code for protein synthesis

Problem: DNA in Nucleus --> protein synthesis occurs in cytoplasm, how do instructions get to construction site?

DNA --> copy small piece --> remove from nucleus --> take to ribosome --> let workers read instructions and assemble --> protein (gene product)

***Check Out*:**

Beginner's Guide to Molecular Biology

DNA - RNA - Protein

Transcribe and Translate a Gene

Google- Protein Synthesis

You Tube- Protein Synthesis

Protein Synthesis

(Objective #8)

RNA- RiboNucleic Acid; nucleotides like DNA except:

1. Ribose rather than deoxyribose sugar
2. Pyrimidines (cytosine and uracil) RNA uses U rather than T

Part I: Transcription, making of mRNA- messenger RNA (Text pg 156-158)

-"Reads", copies or **TRANSCRIBES** (**transcription**) DNA code, takes message (copy) to cytoplasm

Part II Translation, using tRNA- transfer RNA to translate mRNA code

rRNA- ribosomal RNA; Ribosomes
-site of protein synthesis, RIBOSOMES made of RNA
-site where code is translated (decoded)

3 parts: Initiation, Elongation, Termination (text pgs 159-162)

-clover leaf shape- string of paired and unpaired nucleotides
-translates code contained on mRNA

1. every 3 bases in DNA (or mRNA copy) codes for one Amino Acid
2. tRNA translates and carries appropriate amino acid to ribosome
3. at ribosome tRNA deposits amino acid coded for and A.A.chain (protein) is created.

THE PROCESS: DIAGRAM FORM (Text pgs 158, 160-162)

DNA vs. RNA (Objective #11)

	DNA	RNA
FUNCTION	genes, controls protein synthesis	helper to DNA, involved in actual building (synthesis) of protein
SUGAR	deoxyribose	ribose
BASES	A, C, T, G	A, C, U, G
STRUCTURE	double stranded;	single stranded

complementary base
pairing; helix

T A C A T G G G T C A T A T C

REPLICATE ---->

TRANSCRIBE --->

TRANSLATE ---->

MUTATIONS- (Objective #13, 14) Text pgs.166-169 - an inheritable change in a genetic character resulting either from a change in a gene at a specific point or an alteration of chromosome structure.

Check Out:

1. **Point Mutation** - a mutation that involves a single base pair. Usually a substitution.

-may result in no noticable change or code for different protein (amino acid) resulting in something as serious as PKU or Sickle cell

Silent, Nonsense, Missense

-Spontaneous Mutations
Tautomeric shift- a shift in the form of a nitrogenous base

2. **Frame Shift pg 167-169-** removal or addition of a base pair, alterations effect everything after the addition or deletion

EX.	**POINT MUTATION**	**FRAME SHIFT MUTATION**
	THE CAT ATE THE RED HAT	THE CAT ATE THE RED HAT
	THE RAT ATE THE RED HAT	THE ATA TET HER EDH AT (DEL C)
	THE CAT ATE THE RED CAT	THE CCA TAT ETH ERE DHA (ADD C)

3. Gross Chromosomal Abberations

Causes- mutagens- environmental substances that cause mutations (text pg 171-173)

Radiation- Ionizing and X-ray ---> Break DNA, causes deletions and translocations

U.V. ---> alters DNA of surface cells (thymine dimers)

**cause primarily Frame Shift type mutations

Organic Chemicals: Pesticides

Cigarette smoke (benzo(a)pyrine) and 9 others
Smoked foods
Agent orange/mustard gas - methylating/ alkylating groups added

**all cause mispairing of bases (Point Mutation) usually a single nucleotide substitution

(Objective #15)
-if mutation in somatic cells (body cells) ---> cancer
-if mutation in gametes (sex cells) ---> genetic defect in offspring

CANCER- (Objective #16) Text pg 178-181 abnormal division of cells; when cells rebel!
Carcinogens- noxious chemicals, radiation, virus

Check Out:

Oncolink
Your Cancer Risk
Introduction to Skin Cancer

-cause alterations in DNA which cause cells to divide uncontrollably (environmental/ self imposed)

-Oncogenes- stretches of DNA capable of transforming normal body cells into tumor cells.

-p53 tumor suppressor genes (component of normal cell control), Apoptosis

*cancer arises when genetic material damaged in a manner that frees the cell from normal constraints of growth

TUMORS- clusters of cancer cells; some grow fast, some grow slow
Benign ("kind")- growth restricted to area of tumor
Malignant ("evil")- breaks from original mass, enabling them to **metastasize** (spread through body)

Treatment- center around removal of tumor (early detection key)
1. Surgery- location dependent
2. Chemotherapy- lowers immune reactions and others
3. Radiation- effective on rapidly dividing cells, however, ...
4. Immune therapy- build bodies own defenses

BACTERIAL DNA (Objective #19, 20)Pioneering Modern Biotechnology

A. **Transformation**- Free DNA in environment becomes incorporated in bacterial cells (Griffiths, Avery)
-genetic change in one strain of bacteria brought about by exposure to freshly killed bacteria of another strain
B. **Transduction** - genetic transfer among bacteria involving the use of a virus as the transmitting agent

1. plasmids used extensively in DNA research; piece of DNA incorporated into existing DNA

Gene Expression/ Regulation (text pg 161-166)

OPERON CONCEPT- (Objective #17)part of each gene acts as a "switch" to either turn "on" or "off" depending on kind of cell or concentrations of gene products (proteins)

*lac operon; pancreas- insulin

Promoter
Protein Coding Region
Termination Sequence
Regulatory regions

Using DNA to our Advantage (chapter 11 text pgs 223-245)

DNA tech.; Gene splicing; Recombinant DNA/ Transgenics
Human insulin: old ---> pancreas of cattle/sheep; new ---> bacterial
Gene Therapy
Forensics
***Check Out* :**

Use of DNA in Identification
Genetically Modified Organisms
To Know Ourselves
The Gene Hunters
Harvest of Fear

CHROMOSOMES- (Objective #21) composed of genes; genes- ~450-1000 nucleotides (DNA)

gene --> mRNA --> protein --> gene expression
Specific location on a chromosome referred to as a gene locus

Chromosome theory- (Objective #22) since there are more traits than there are chromosomes, each chromosome must carry many traits (genes)

**all cells contain an identical copy of every chromosome (w/exception of egg and sperm which have 1/2)

-however, not all cells have all genes "turned on"

(Objective #23)
Diploid- chromosomes found in pairs (2N; N= chromosomes)
Human 2N number is 46

Dog 2N= 78 (this does not mean dogs have more DNA)

Haploid- single set of chromosomes, characteristic of gametes (eggs and sperm)

Human haploid (1N) number is 23

Maternal egg		Paternal sperm		Zygote
1N	+	1N	------>	2N
haploid = 23		haploid = 23		diploid = 46

Back to General Biology at WNCC