UNIT FOUR: DNA, RNA, PROTEIN SYNTHESIS
Chapters 9, 10, and Pg. 127

1. Describe the experiments by Griffith, and Hershey and Chase, that led to the discovery of DNA as the genetic material in cells.

2. Describe the structure of DNA.

3. Explain the process of DNA replication.

*4. Describe the extraction of DNA from plant cells. (LAB)

5. Describe the processes of transcription and translation as they relate to protein synthesis.

6. Compare the differences between DNA and the three types of RNA.

7. Explain how mutations can affect proteins and protein synthesis.

8. Summarize the role of oncogenes in the development of cancer.

*9. Identify environmental causes of mutations.

Note:
* items are NOT in the book.
UNIT 4 VOCABULARY

DNA Vocabulary
double helix
nucleotide
sugar (deoxyribose)
adrenaline/thymine -
cytosine/guanine
hydrogen bonds
phosphate
base
Watson and Crick
replication
base pairs
complementary pairs
DNA polymerase
triplet code
replication
helicase

RNA Vocabulary
linear
nucleotide
sugar (ribose)
adrenaline/uracil
cytosine/guanine
protein synthesis
transcription
mRNA
tRNA
triplet codon
anticodon
ribosome
rRNA
translation
start codon
stop codon
mRNA editing
heterogenous mRNA
mature mRNA
intron
exon
peptide bond
amino acids
mutation
deletion
point mutation
oncogene
mutagen
carcinogen
DNA Molecule: Two Views
Replication of DNA

Uncoiling  Unzipping  Adding new parts

Two DNA molecules  Recoiling
Chapter 9
Interpreting Diagrams: Use the figure below to answer questions 1–3.

1. In the space provided, identify the structures labeled A–E.
   A. ______________________________________
   B. ______________________________________
   C. ______________________________________

2. What do the lines connecting the two strands (C) represent? Why are there three lines connecting the strands in some instances and only two lines in others?

3. Suppose that a strand of DNA has the base sequence ATTCCG. What is the base sequence of the complementary strand?
Pre-Lab: DNA Extraction

**Directions:** Read the lab on pkt.1 pages 6-7 before answering these questions. Answer questions using **complete sentences** before coming to class to perform the experiment.

1. Using your class notes (and brain), draw and label a DNA molecule consisting of 8 nucleotides TOTAL. Label parts the including: sugar, phosphate, nitrogen base, hydrogen bond, covalent bond, nucleotide.

2. **Why** must we mash the strawberries?

3. How long should you pulverize the strawberries before adding the extraction buffer?

4. What makes the DNA precipitate out of solution? (What do you do to make the DNA become visible?)

5. How will you remove the extracted DNA from the test tube? (Be specific.)
6. What should you SPECIFICALLY do when you’ve successfully extracted your DNA at the end of lab?
EXTRACTION OF DNA FROM STRAWBERRIES

INTRODUCTION:
Strawberries are excellent organisms to use for DNA extraction. One reason they are so useful is because they are soft and easy to pulverize. Also, ripe strawberries are producing pectinases and cellulases which are already breaking down the strawberry’s cell walls. Most interestingly, strawberries have ENORMOUS genomes. They are octoploid, which means they have eight sets of each chromosome. Your cells are considered diploid because they have two sets of each chromosome: one set from your mother and one set from your father. Therefore, strawberries have 4 times the amount of DNA in each cell compared to your cells!

After you have pulverized the strawberries, you will add extraction buffer. The extraction buffer contains detergent and salt. The detergent (from shampoo) helps to dissolve the phospholipid bilayers of cell membranes and organelles. The salt helps to keep the proteins in the extract layer so the proteins are separated from the DNA and the DNA floats above the extract layer.

DNA is not soluble in ethanol. When molecules are soluble, they are dispersed in the solution and therefore are not visible. When molecules are insoluble, they clump together, and become visible. The colder the ethanol, the less soluble the DNA. Therefore, it is important for the ethanol to be kept on ice.

MATERIALS PER GROUP:
• heavy duty ziplock plastic bag
• 10 mL DNA extraction buffer
• ice cold ethanol
• wooden stick
• one strawberry (fresh)
• filtering apparatus: cheesecloth, funnel, 50mL beaker
• small test tube

DNA Extraction Procedure: Follow these steps and you should have a successful extraction experience.

0. SAFETY: Put on goggles!

1. Place 1 fresh strawberries in a Ziploc® freezer storage bag. Remove the air from the bag, seal it, and thoroughly mash the contents in the bag with your hands for approximately 5 minutes. If you get tired, let your lab partner mash for a while. (You might choose to squish the contents in the bag on the table top with your hands.) THE LONGER YOU MASH, THE BETTER YOUR RESULTS!

2. Add 10 ml of the DNA extraction buffer into the plastic bag. Remove the air from the bag, seal it, and mix the mashed strawberries and DNA extraction buffer together for 5 minutes. Try not to allow the strawberry/buffer mixture foam too much.

3. Place a funnel into a test tube and place a piece of cheesecloth into the top of the funnel. Pour the strawberry mixture into the piece of cheesecloth that has been placed in the top of the funnel. Twist each end of the cheesecloth (Figure 1) and filter (strain) the mixture into the test tube. Fill approximately 1/2 of the test tube with the strawberry mixture.
4. Remove the funnel from the test tube, and discard the cheesecloth with the leftover strawberry mixture into the garbage.

5. Use a pipette to drizzle approximately 10 mL of ice cold ethanol down the inside of the test tube (Figure 2). The ethanol should form a layer on top of the strawberry mixture. A white, stringy precipitate containing DNA should begin to form (Figure 3).

6. Place the blunt end of a wooden skewer into the center of the white, stringy mass. Slowly rotate (DO NOT STIR) the skewer in one direction. The DNA should spool onto the wooden skewer (Figure 4). Remove the skewer and observe the DNA that you have extracted.

**Analysis Questions: Answer using complete thoughts and sentences on separate paper.**

1. a) List your observations of what the DNA looked like. Include qualitative and quantitative observations.
   b) Compare these observations with your previous ‘hypothesis’ of what you imagined DNA looked like.

2. If DNA is in cells (which are microscopic), why is it that we could see the DNA?

3. Is it likely that the cells of living organisms other than strawberries could serve as a source of DNA? Explain your answer. Cite at least TWO other potential sources for DNA.

4. Why was it important to keep the ethanol ice cold?

5. Name and describe the purpose of the two components of the extraction buffer solution.

6. How do the enzymes pectinase and cellulase aid in the extraction of DNA from strawberries?

7. Altering which part of the procedure would allow you to potentially extract more DNA? Explain.

8. How is the extraction of DNA useful to biologists? **HINT: look up the answer using an outside source!**

9. State two safety precautions that specifically related to this lab. Explain how you maintained a safe lab environment?
Translation

tRNA AND AMINO ACIDS COMBINE

TRANSLATION BEGINS

TRANSLATION CONTINUES

FINISHED PROTEIN OR POLYPEPTIDE FORMED
TRANSLATION KEY POINTS TO KNOW:
Where translation occurs

Materials needed to construct a protein

How translation begins

How amino acids are joined/proteins made

The role of codons and anticodons in translation process

Where are codons located?

Where are anticodons located?

How process creates the correct sequence of amino acids and builds the correct protein

How translation stops/ends (two ways)

Product of translation
**PROTEIN SYNTHESIS**

*HINT*: Transcription/translation does not begin until the START codon is read on DNA. What is start codon for RNA? How will you determine “start” for DNA?

<table>
<thead>
<tr>
<th>DNA</th>
<th>mRNA(codon)</th>
<th>tRNA(anticodon)</th>
<th>AMINO ACIDS</th>
<th>DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5'</td>
<td></td>
<td></td>
<td></td>
<td>3'</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>T</td>
<td>A</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>A</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>T</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>T</td>
<td>A</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>T</td>
<td>G</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>G</td>
<td>T</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>T</td>
<td>A</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
<td></td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>3'</td>
<td>SENSE</td>
<td>TRANSCRIPTION</td>
<td>TRANSLATION</td>
<td>AMINO ACIDS</td>
</tr>
<tr>
<td>5'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 10
Interpreting Tables: Use the table below to complete items 1–17.

<table>
<thead>
<tr>
<th>First base</th>
<th>UUU</th>
<th>UUC</th>
<th>UUA</th>
<th>UUG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phenylalanine</td>
<td>Leucine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UCU</td>
<td>UCC</td>
<td>UCA</td>
<td>UCG</td>
</tr>
<tr>
<td></td>
<td>Serine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UAU</td>
<td>UAC</td>
<td>UAA</td>
<td>UAG</td>
</tr>
<tr>
<td></td>
<td>Tyrosine</td>
<td>Stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UGU</td>
<td>UGC</td>
<td>UGA</td>
<td>UGG</td>
</tr>
<tr>
<td></td>
<td>Cysteine</td>
<td>Stop</td>
<td>Tryptophan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>C</td>
<td>A</td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>CUU</td>
<td>CUC</td>
<td>CUA</td>
<td>CUG</td>
</tr>
<tr>
<td></td>
<td>Leucine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCU</td>
<td>CCC</td>
<td>CCA</td>
<td>CCG</td>
</tr>
<tr>
<td></td>
<td>Proline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAU</td>
<td>CAC</td>
<td>CAA</td>
<td>CAG</td>
</tr>
<tr>
<td></td>
<td>Histidine</td>
<td>Glutamine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CGU</td>
<td>CGC</td>
<td>CGA</td>
<td>CGG</td>
</tr>
<tr>
<td></td>
<td>Arginine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>C</td>
<td>A</td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>AUU</td>
<td>AUC</td>
<td>AUA</td>
<td>AUG</td>
</tr>
<tr>
<td></td>
<td>Isoleucine</td>
<td>Start</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ACU</td>
<td>ACC</td>
<td>ACA</td>
<td>ACG</td>
</tr>
<tr>
<td></td>
<td>Threonine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AAU</td>
<td>AAC</td>
<td>AAT</td>
<td>AAG</td>
</tr>
<tr>
<td></td>
<td>Asparagine</td>
<td>Lysine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AGU</td>
<td>AGC</td>
<td>AGA</td>
<td>AGG</td>
</tr>
<tr>
<td></td>
<td>Serine</td>
<td>Arginine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>C</td>
<td>A</td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>GUU</td>
<td>GUC</td>
<td>GUA</td>
<td>GUG</td>
</tr>
<tr>
<td></td>
<td>Valine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GCU</td>
<td>GCC</td>
<td>GCA</td>
<td>GCC</td>
</tr>
<tr>
<td></td>
<td>Alanine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GAU</td>
<td>GAC</td>
<td>GAA</td>
<td>GAG</td>
</tr>
<tr>
<td></td>
<td>Aspartic acid</td>
<td>Glutamic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GGU</td>
<td>GGC</td>
<td>GGA</td>
<td>GGG</td>
</tr>
<tr>
<td></td>
<td>Glycine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td>C</td>
<td>A</td>
<td>G</td>
</tr>
</tbody>
</table>

Complete the table below showing sequences of DNA, mRNA codons, anticodons, and corresponding amino acids. Use the list of mRNA codons in the table above to assist you in completing this exercise. Remember that the genetic code is based on mRNA codons.

<table>
<thead>
<tr>
<th>Decoding DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
</tr>
<tr>
<td>mRNA codon</td>
</tr>
<tr>
<td>Anticodon</td>
</tr>
<tr>
<td>Amino acid</td>
</tr>
</tbody>
</table>

Determine how the mutations below will affect each amino acid sequence. Use the mRNA codons in the table to complete items a–d below. In the space provided, write the names of the amino acids that correspond to each mRNA sequence and mutation given.

Example:
mRNA sequence: UGU-CCG  cysteine-proline
mutation sequence: UGC-CGC  cysteine-arginine

13. mRNA sequence: GAA-CGU  __________________________
mutation sequence: GAU-CGU  __________________________

14. mRNA sequence: AUC-UGC  __________________________
mutation sequence: AUC-UGG

15. mRNA sequence: UGU-CCU-CCU
mutation sequence: UGU-UUC-CCU

16. mRNA sequence: GGG-UUA-ACC
mutation sequence: GGU-UAA

17. What kind of mutation occurred to the mRNA sequence in item 16 above? Explain.

**Fill ins:** Complete each statement by writing the correct term or phrase in the space provided.

1. Instead of the base thymine found in DNA, RNA has a base called __u__________.

2. Transcription begins when an enzyme called __R________________   binds to the beginning of a gene on a region of DNA called a promoter.

3. The instructions for building a protein are written as a series of three nucleotide sequences called ___c____________.

4. Insertions, deletions and point mutations are types of __m__________________.

Questions 11–13 refer to the following figure.

5. The processing of information from DNA into proteins, as shown above, is referred to as ________________________________.

6. Stage A is called ________________________________.

7. Stage B is called ________________________________.
Multiple Choice: In the space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

8. In what kinds of cells do mutations occur?
   a. body cells  
   b. gametes  
   c. reproductive cells  
   d. All of the above

9. Which of the following represents the codons that correspond to this segment of DNA: TATCAGGAT?
   a. AUA—GUC—CUA  
   b. ATA—GTC—CTA  
   c. AUAGU—CCUA  
   d. ACA—CUC—GUA

10. Which of the following are the anticodons that correspond to the mRNA codons CAG—ACU—UUU?
    a. GTC—TGA—AAA  
    b. GUC—UGA—AAA  
    c. glutamine—threonine—phenylalanine  
    d. GAC—UCA—AAA

11. Because the genetic code is the same in all organisms, it appears that
    a. the genetic code evolved more than once.  
    b. the codon GUC codes for different proteins in different organisms.  
    c. thymine will soon replace uracil in RNA.  
    d. all life-forms have a common ancestor.
CONCEPT GENERALIZATIONS: UNIT FOUR

Create concept generalizations using all the words listed for each concept. Limit the length of your generalization to 5 sentences. Write you generalizations on a separate piece of paper using complete sentences. UNDERLINE all key words used to create your generalizations.

You might want to organize the terms first, either by creating lists of words that are generally associated with each other or creating a concept map showing how terms are related. Then, write your concept generalization sentences.

If you are explaining a process, make sure your steps and terms used are in chronological order!

1. **DNA STRUCTURE:** nucleotide, deoxyribose, phosphate, gene, nitrogen base, adenine, cytosine, thymine, guanine, hydrogen bond, double helix

2. **REPLICATION:** explain process using the following terms...
   G,C,A,T, unzip, replication, complementary nucleotides, helicase, DNA polymerase, nucleus, nitrogen base, hydrogen bonds, ATP

3. **RNA STRUCTURE:** G, C, A, U, single stranded, RNA polymerase, nucleus, DNA, nucleotide, ATP

4. **TRANSCRIPTION:** explain the process using the following terms...
   DNA (sense strand), stays in nucleus, leaves nucleus, enzymes, cytoplasm, intron, exon, premRNA, mRNA, RNA polymerase

5. **TRANSLATION:** explain the process using the following terms...
   mRNA, tRNA, rRNA (ribosome), amino acids, complementary base pairing, peptide bond, cytoplasm, anticodon, start codon, stop codon, codon
6. **MUTATION**: nucleotide, DNA, mRNA, protein, shape/ function, harmful, beneficial, variation, amino acid sequence, deletion, addition, translocation, inversion, mutagen, carcinogen

**REVIEW: DNA/RNA/Protein Synthesis-The Genetic Code**

**Chapter 9: DNA**

1. What are genes?

2. Who discovered the structure of DNA? What information did they use to determine the structure?

3. What are the 3 components of a nucleotide?

4. What are the 4 bases of DNA? Write them to show which 2 will pair.

5. What is it called when DNA copies itself?

6. What are the rungs of the DNA ladder made of?

7. What are the uprights of this ladder made of?

8. What name is given to the spiral shape of the DNA molecule? What does “double” refer to and what does “helix” mean with respect to the molecule’s shape.

9. Summarize the steps of DNA replication.
Chapter 10: Protein Synthesis

10. Where is the information for making all proteins stored?

11. What are the building blocks of proteins?

12. How many nucleotides are needed to code for one amino acid?

13. Describe 2 ways in which RNA differs from DNA.

14. What is transcription?

15. Summarize the steps of transcription.

16. What is translation?

17. Where is an a anticodon found? The codon?
<table>
<thead>
<tr>
<th>Building Name of</th>
<th>DNA $\rightarrow$ DNA</th>
<th>RNA $\rightarrow$ RNA</th>
<th>DNA $\rightarrow$ RNA</th>
<th>Protein</th>
<th>DNA $\rightarrow$ DNA</th>
<th>RNA $\rightarrow$ Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>