OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

# Unit 6, Topic 3: Protein Synthesis

*By the end of this topic, you should be able to...*

1. *Describe the differences between DNA and RNA*
2. *Identify and order the steps in protein synthesis (transcription and translation)*
3. *Explain the purpose of the molecules used in both transcription and translation*
4. *Use a codon chart to determine a protein sequence based on an mRNA code*
5. *Compare and contrast gene and chromosomal mutations*
6. *Predict the effect of DNA mutations on the resulting protein*

## What are Proteins?

1. Hershey and Chase's virus experiment (Topic #1) showed that DNA was the genetic material of the cell.
2. Proteins are the workhorses of the cell...they do a lot of different jobs!
   - A) Antibodies - immune system/defense
   - B) Structure - hair/nails
   - C) Speeding up reactions - enzymes (-ase)
   - D) Transport - hemoglobin (carries oxygen in blood!)
   - E) movement - muscle

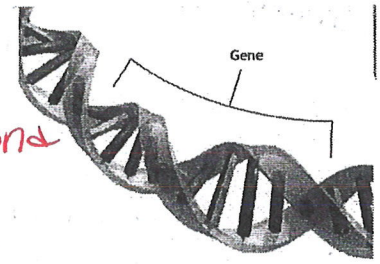
Unit 2 recap!

## How do our Cells Make Proteins?

3. DNA contains genes, sections of nucleotide chains.

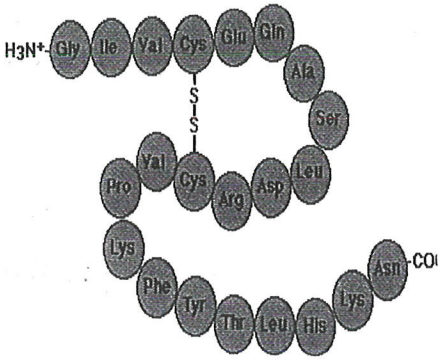
Genes code for polypeptides (proteins).

Polypeptides are amino acids chains. — the bond that holds amino acids together is a peptide bond




4. **The Dilemma:** DNA is found in the nucleus, but proteins are made in the ribosomes. How do we get the message from one place in the cell to another?

5. **The Solution:** A molecule called RNA (mRNA) carries the message. It's small enough to fit through the pores / holes in the nuclear membrane.




**Putting it together:**

- DNA is responsible for controlling the production of proteins in the cell, which is essential to life!
  - DNA→RNA→Proteins ← central dogma of Biology
- Chromosomes contain several thousand genes, each with directions to make one protein

**Where are Proteins Produced?**

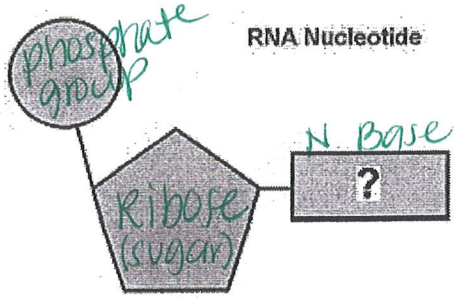
- Proteins are produced on Ribosomes!
- Found in two places:
  - Free floating in cytoplasm
  - Attached to endoplasmic reticulum
- How does information needed to build a protein gets delivered from the DNA to the ribosomes?
  - With the help of RNA in a process called protein synthesis
    - ↓ to build or make

OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

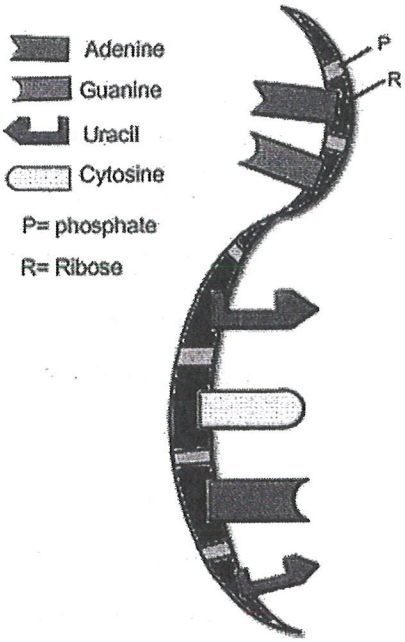
## What is RNA?

- ***RNA*** stands for ribonucleic acid — just like DNA!
- One subunit is called a nucleotide (monomer)
  - 1 5-carbon sugar (ribose)
  - 1 phosphate group
  - 1 nitrogenous base
- Three types of RNA: mRNA, tRNA, rRNA




## A Closer Look at mRNA

- How is mRNA different from DNA?
  - SINGLE stranded
  - Shorter and able to leave the nucleus
  - The sugar is RIBOSE
  - There is a different base
    - Uracil (U) takes the place of Thymine (T)
- The job of mRNA is to take directions for one gene and transport it to a ribosome in the cytoplasm.
  - This is so a cell can begin assembling amino acids, the building blocks (monomer) of proteins!
  - It's sending a message on how to do the job!




## Protein Synthesis

- ***Protein synthesis*** is a two stage process: Transcription and Translation
  - A messenger molecule (mRNA) carries instructions from DNA to ribosomes
    - DNA CANNOT leave the nucleus; mRNA can!
    - mRNA makes it possible for proteins to be assembled by ribosomes outside the nucleus

## Protein Synthesis: Transcription (transcribe = copy)

Transcription: DNA → mRNA (nucleus)

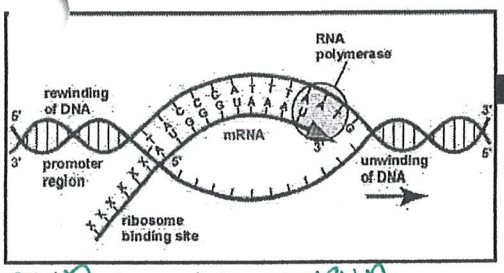
- ***Transcription*** is when DNA is turned to mRNA
- Happens when proteins need to be made in the cytoplasm
- Since DNA CANNOT leave the nucleus, it is transcribed into RNA (DNA→RNA)
  - Transcribe: to copy (copy in the same nucleic acid language, but only what is needed!)

- How does it happen?
  1) After an enzyme targets the portion of the DNA that should be copied (initiation), the sections of DNA (genes) will temporarily unwind to allow mRNA to transcribe (copy). This will continue until an enzyme signals "the end"
  2) mRNA leaves the nucleus, travels into the cytoplasm and attaches to a ribosome
  3) The "message" from DNA can now be translated to make a protein

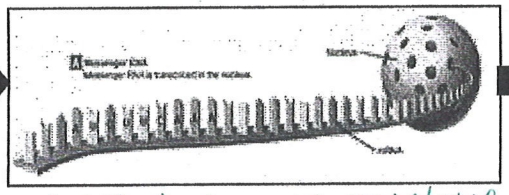
OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

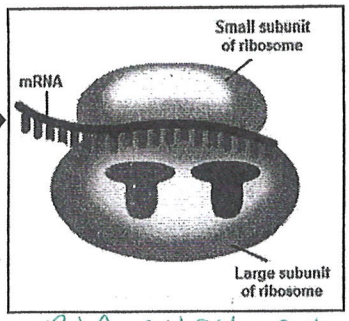
*Think about it:* What is happening in each photo below during transcription?




DNA unzips, mRNA built



mRNA leaves nucleus via nuclear pores




mRNA attaches to ribosome

- Transcribing DNA to mRNA is very easy if you remember these complementary pairs!
  - C (in RNA) will attach to a G (in DNA)
  - G (in RNA) will attach to a C (in DNA)
  - A (in RNA) will attach to a T (in DNA)
  - U **(in RNA)** will attach to a A (in DNA)
- Try it!
  - A piece of DNA reads: T A G C A T T C C G A U
    Transcribe to mRNA: AUCGUAAGGCUA
  - 1 side of DNA reads: A A G C G T A T C C C G
    Transcribe to mRNA: _____

**Protein Synthesis: Translation** = mRNA → Amino Acid (protein) @ ribosome)

- ***Translation***→ The process in which mRNA is used as a blueprint to form chains of amino acids (RNA→Protein)
  - Amino acids linked together form a protein
  - Translate: To change a sentence from one language (nucleic acid) to another (amino acid or protein)
- Every 3 letters on an mRNA chain = CODON
- Each codon (3 DNA letters) = 1 Amino Acid
- Given the mRNA, we can read a codon chart to translate it into amino the amino acid it codes for!
  - Remember, 1 word in nucleic acid language is a codon (three nucleotides)

*Think about it*: What amino acid is coded for?

1) AUG start/methionine
2) GUC _____
3) GCC _____
4) CGA _____
5) UAA _____

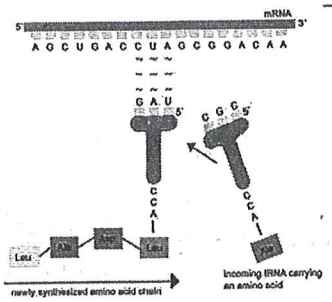
| First Letter | Second Letter: U | C | A | G | Third Letter |
|---|---|---|---|---|---|
| U | phenylalanine | serine | tyrosine | cysteine | U |
| | phenylalanine | serine | tyrosine | cysteine | C |
| | leucine | serine | stop | stop | A |
| | leucine | serine | stop | tryptophan | G |
| C | leucine | proline | histidine | arginine | U |
| | leucine | proline | histidine | arginine | C |
| | leucine | proline | glutamine | arginine | A |
| | leucine | proline | glutamine | arginine | G |
| A | isoleucine | threonine | asparagine | serine | U |
| | isoleucine | threonine | asparagine | serine | C |
| | isoleucine | threonine | lysine | arginine | A |
| | (start) methionine | threonine | lysine | arginine | G |
| G | valine | alanine | aspartate | glycine | U |
| | valine | alanine | aspartate | glycine | C |
| | valine | alanine | glutamate | glycine | A |
| | valine | alanine | glutamate | glycine | G |

OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

- ***Translation*** occurs in a ribosome in ALL cells
- Uses all three forms of RNA (mRNA, rRNA, tRNA)
- DNA is not directly used!

**tRNA: A Closer Look**




- Notice the tRNA is carrying the amino acid leucine, coded for by the sequence "CUA"
- The tRNA knows how to match using bases!
- So…mRNA codon reads "CUA," so the tRNA anticodon will be "GAU"

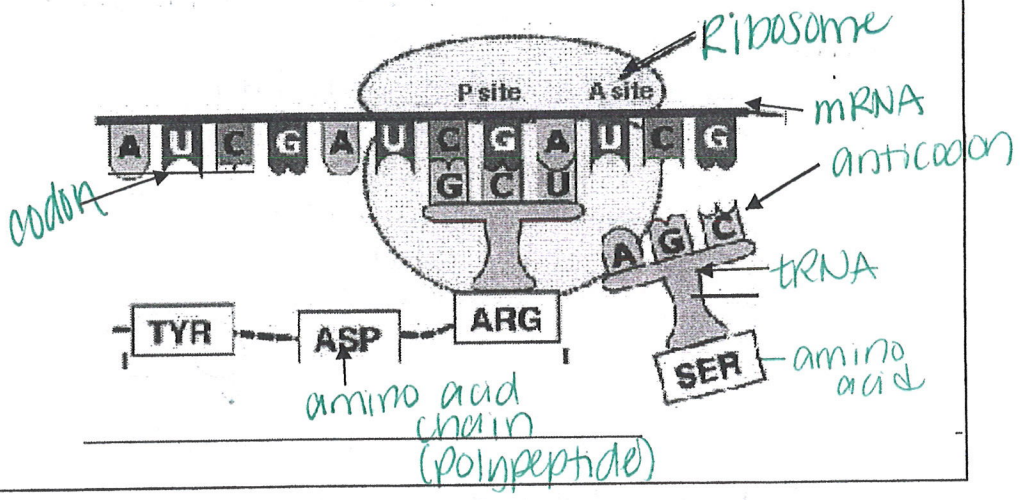
**Steps of Translation**

1) The mRNA leaves the nucleus and lands on a ribosome (rRNA)
2) tRNA (with correct anticodon) lands on the ribosome opposite a codon on the mRNA
3) The tRNA leaves the ribosome, but the amino acid that it coded for stays on the ribosome to wait for next codon to be read
4) The ribosome moves to the next codon bringing in another amino acid to the growing protein chain

- The amino acid chain will ALWAYS begin with the "start codon"- AUG
- The tRNA will continue to add amino acids until it reaches a "stop codon" (UAA, UAG, UGA)
- When it reaches a stop codon, then a complete protein has been built! The protein unattaches from the ribosome.

*Think about it*: Label the diagram of translation to the right with the following terms!

a) ribosome
b) mRNA
c) tRNA
d) codon
e) anticodon
f) amino acid chain




- Given the strand of DNA→ **ATC**
  - What would it's *complementary* DNA strand read? TAC
  - Now, transcribe the DNA to mRNA _____
  - What amino acid does the codon code for? (use chart) _____
  - What would the anticodon on tRNA read? _____

OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

- Given the strand of DNA→ **TGA**
  - What would it's *complementary* DNA strand read? _____
  - Now, transcribe the DNA to mRNA _____
  - What amino acid does the codon code for? (use chart) _____
  - What would the anticodon on tRNA read? _____

**Mutations**

- Changes to DNA are called mutation
  - Change the DNA
  - Change the mRNA
  - May change protein
  - May change trait

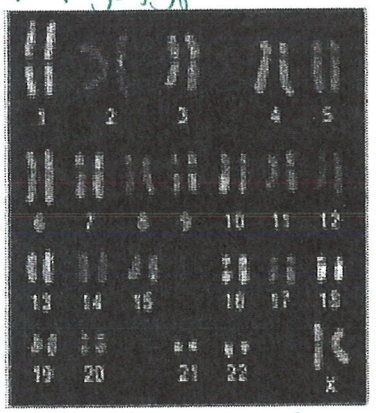
**2 Main Types of Mutations:**

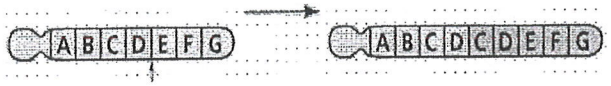
1.) Chromosomal Mutations- a mutation involving many genes
2.) Gene Mutations- a mutation that involves a few nucleotides

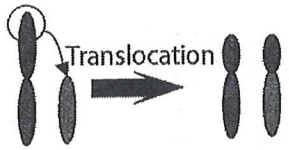
**Chromosomes and Chromosomal Mutations:**

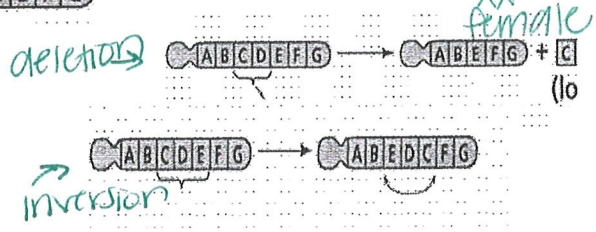
- Humans have 23 pairs of chromosomes, with one set of chromosomes from each parent.
- The chromosomes are coiled up DNA.
- Under normal conditions, all of the chromosomes are inherited in tact.
- When will a mutation be passed onto offspring?
  1.) When it is in an EGG or SPERM cell (gamete)
- Chromosomal mutations occur when there is a change in structure or number of chromosomes (LARGE SCALE)
- There are FIVE types of chromosomal mutations:
  1.) Deletion
  2.) Duplication
  3.) Inversion
  4.) Translocation
  5.) Nondisjunction

Karyotype:






*Most chromosomal mutations are:* lethal

**Gene Mutations:**

- *Small scale:* one gene is affected
- Any change to the DNA sequence of a gene:
  - Nucleotides/Bases may be added, missing, or changed

**Types of Mutations**

- Changes to the letters (ATGC bases) in DNA!
- ***Point mutation***→ change to ONE letter in the DNA!

Name: _____
DNA/RNA/Protein Synthesis

- May (or may not) cause a change to protein

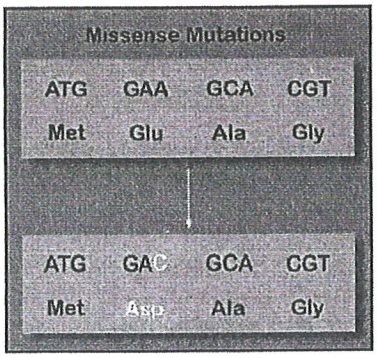
- ***Frame shift mutation***→ addition of a NEW letter; or deletion of a letter!
  - Both of these SHIFT DNA so it changes how the codons are read
  - Big changes to protein

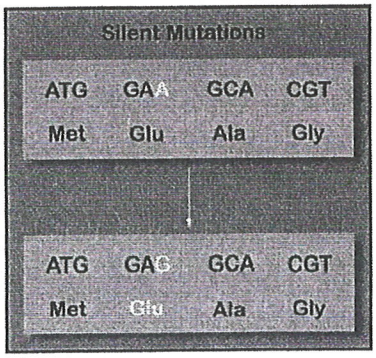
**Point Mutations**

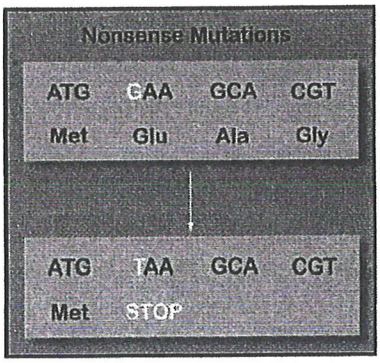
***Missense mutation*** = code for a different amino acid (Ex. Sickle Cell Anemia)

***Silent mutation***= code for the same amino acid

***Nonsense mutation***= code for a stop (can change protein!)

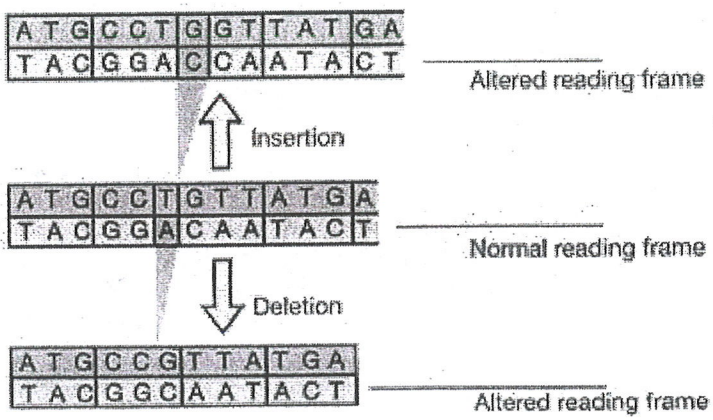



**Frameshift Mutations**

- Addition or Deletion of one or more bases
  - Change the meaning of the whole protein!
- ***Addition (insertion)***→ adding a base
- ***Deletion***→ removing a base




***[[Language Target for Topic 3: I can create a Venn diagram to compare and contrast RNA and DNA; I can transcribe a strand of DNA into mRNA, and then translate it into the appropriate amino acid sequence using the codon chart; I can locate an mRNA codon on the codon chart to determine which amino acid it codes for; I can discuss and compare the various mutations]]***

OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

ad each term or phrase in the left-hand column of the following table. If the term or phrase applies to DNA, ace a check mark in the column labeled DNA. If it applies to RNA, place a check mark in the column labeled RNA. If it applies to both nucleic acids, place a check mark in both columns. **Place the terms in the Venn Diagram.**

| Term or Phrase: | DNA | RNA |
|---|---|---|
| Nucleotides | | |
| Deoxyribose | | |
| Ribose | | |
| Single-stranded | | |
| Double-stranded | | |
| Nitrogen bases | | |
| Thymine | | |
| Uracil | | |
| Double Helix | | |
| Replication | | |
| Transcription | | |
| Messenger | | |
| More than one form | | |
| Found in the nucleus | | |
| Leaves the nucleus | | |
| Does not leave the nucleus | | |

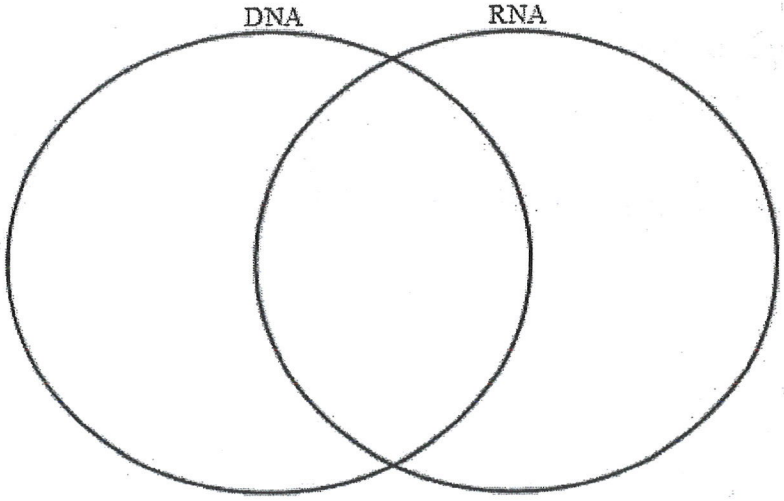
DNA: ATACGAAATCGCGATCGCGGCGATTCGG

mRNA:

Codon:

Anticodon:

Amino Acids:




***Directions:*** *Cystic Fibrosis is a disorder where the individuals have lung and kidney problems. The disorder is caused by a mutation in one of the individual's genes. Complete the boxes below by finding the mRNA and amino acid sequence. Compare the mutant DNA strands to the original strand. Circle the mutation in the mutant DNA strands. Classify each mutation.*

1. Normal Gene: **A C C A T T A A A G A A A A T A T C A T C T T T G G T G T T T C C T A T G A T**

   mRNA sequence: _____

   Amino acid sequence: _____

2. Mutant Gene 1: **A C C A T T A A A G A A A A T A T C A T C G G T G T T T C C T A T G A T**

   mRNA sequence: _____

   Amino acid sequence: _____

   Type of Mutation: _____

3. Mutant Gene 2: **A C C A T T A A A G A A A A A A T C A T C T T T G G T G T T T C C T A T G A T**

   mRNA sequence: _____

   Amino acid sequence: _____

   Type of Mutation: _____