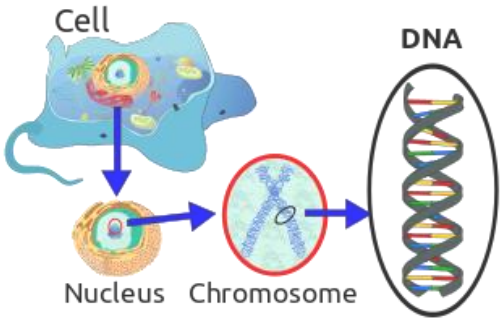
OPHS Biology
Unit 6 Notes

Name: _____
DNA/RNA/Protein Synthesis

Unit 6, Topic 1: DNA History and Structure

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

1. *Identify the experiments and scientists involved in the discovery of DNA*
2. *Describe the structure of the DNA molecule*



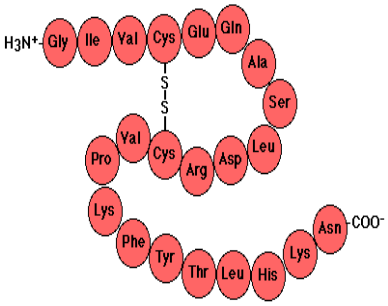
Review:

- *Define monomer:* _____
- *Define polymer:* _____
- *Monomer of nucleic acids:* _____
- *Who discovered the structure of DNA and what is it?*

_____

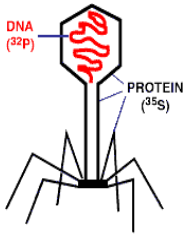
History of DNA

- Early scientists believed that _____ was the genetic material of the cell.
  - **Explain why:**
- Proteins are made of 20 different _____
- Long chains of amino acids make up _____ →
- Frederick Griffith worked with what type of bacteria?

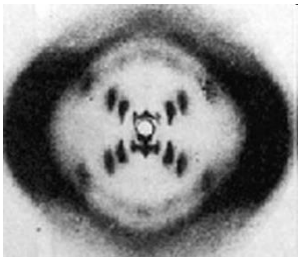


- What did he find to be true after his experiments with the S and R strains of bacteria?

- Griffith's experiment proved that _____ is the cell's genetic material.

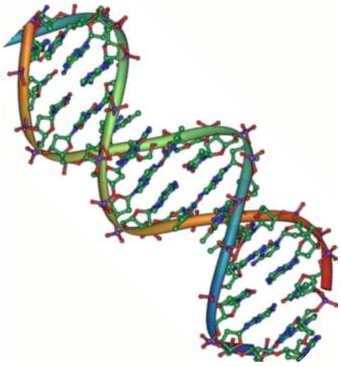


- How did Hershey and Chase's work with viruses help to support this idea?



- _____took x-ray diffraction photographs of DNA crystals.
- _____ and _____ used the x-ray diffraction photos to come up with the _____ model of DNA.

DNA Structure



- DNA is an example of which type of macromolecule (carbohydrate, lipid, protein, or nucleic acid)? _____
- The full name of DNA is _____
- DNA is made of monomers called _____
- What is the function of DNA? _____
  _____
- DNA is made of two coiled strands called the _____

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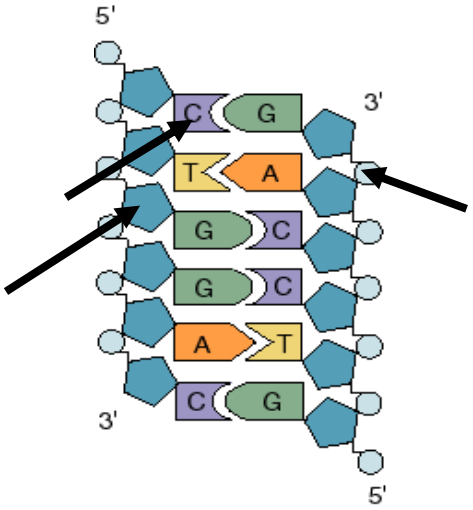
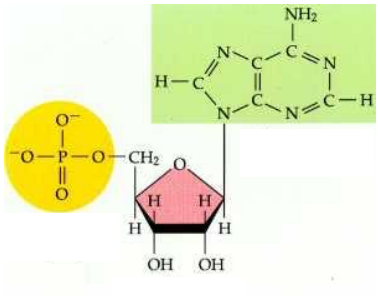
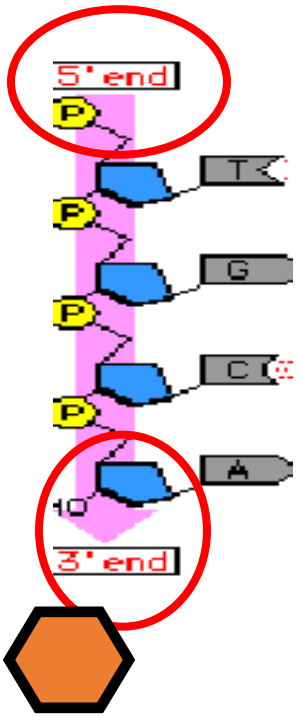
- The "backbone" of each strand is made of sugars called _____ bonded to _____ (PO4) groups.
- The "rungs" of the ladder are made of _____ bonded together by weak _____ bonds.
- **Label** a ***sugar, phosphate,*** and ***base*** in the picture to the right.



- Each nucleotide is made of 3 parts.
  - _____
  - _____
  - _____

Label *the three parts of the nucleotide pictured below:*

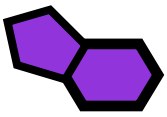




- The part of a DNA strand that ends with the _____ is called the **5 prime (5') end**.
  - **Ph**osphate = **F**ive
- The part of a DNA strand that ends with the ___ the **3 prime (3') end.**
- Explain the meaning of the following statement…

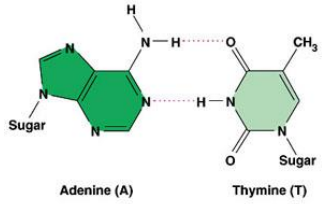
*"The strands of the double helix are **antiparallel**."*

_____
_____

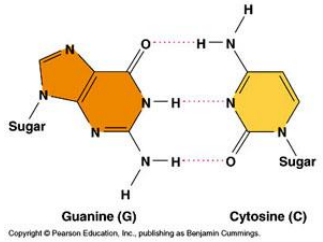


- There are 2 types of nitrogenous bases. _____ have a **double-ring structure**, and _____ have a **single-ring structure**.
  - The two **purines** are _____ and _____.
  - The two **pyrimidines** are _____ and _____.
    - Purines can only pair with pyrimidines. They are connected by _____ bonds. (See picture to the right)
    - *Why would it be a problem for the double structure if purines paired with purines and pyrimidines with pyrimidines?*

      _____
      _____
      _____



- The process of specific bases pairing together to form the rungs of the ladder is called _____
  - Chargaff's rules state that
    - **Adenine** must pair with _____
    - **Guanine** must pair with _____



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- A scientist named **Erwin Chargaff** showed the _____ of the four bases on DNA. In the DNA of a body cell, he saw the following percentages.

  A = _____ T = _____ G = _____ C = _____

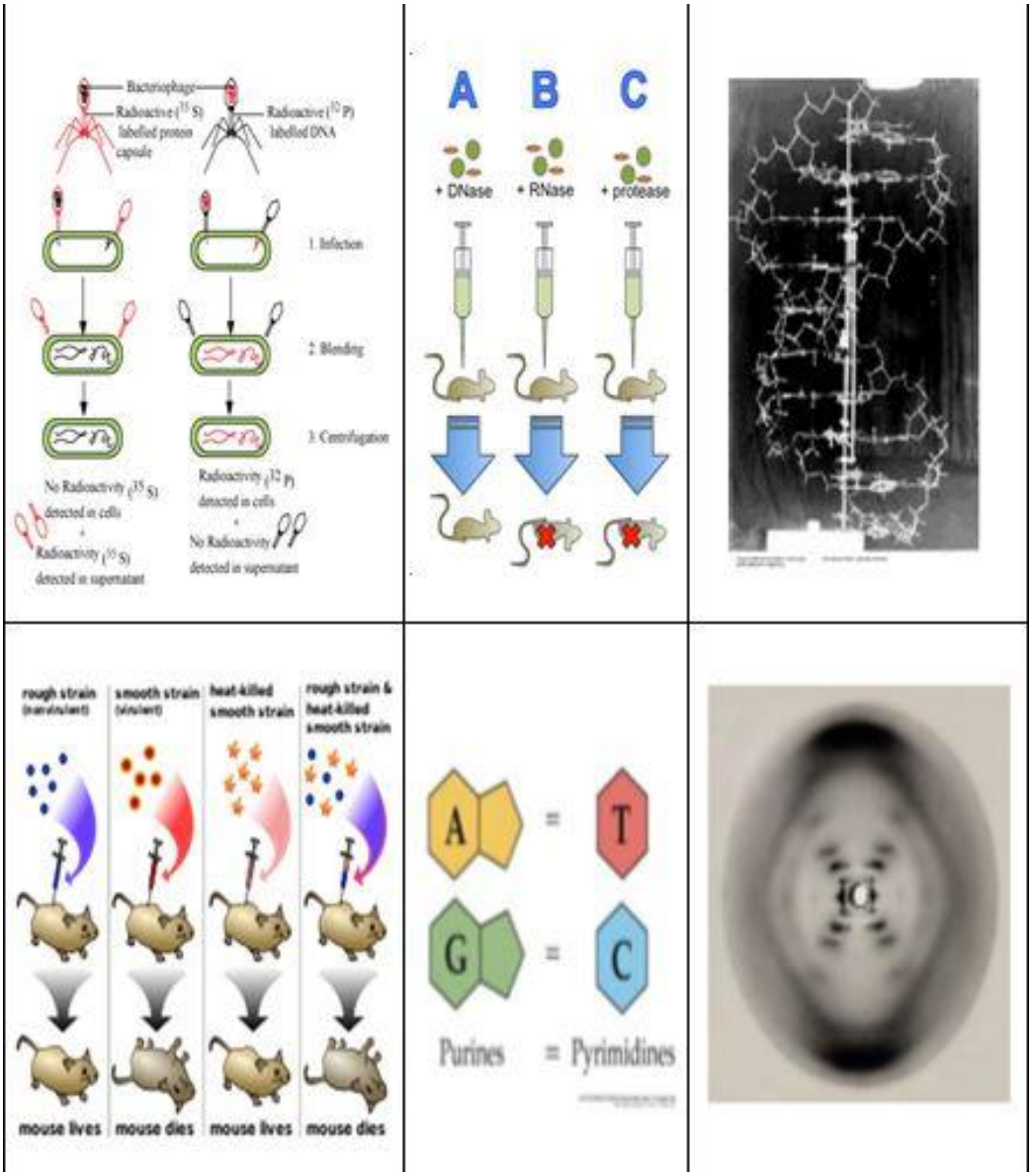
  - What do you notice about these numbers?_____
- **Practice Question #1:** If there is 30% adenine, how much cytosine is present? _____
- **Practice Question #2:** Write out the sequence of a strand complementary to the following strand.

T T A G C A T G G

[[*Language Target for Topic 1: I can match the scientists and their research that aided in the discovery of DNA; I can create a model of DNA]]*

1. Provide the name of the scientist(s) associated with each image provided. Do so by filling their name(s) in beneath the appropriate picture.

2. Complete the DNA Structure coloring assignment.



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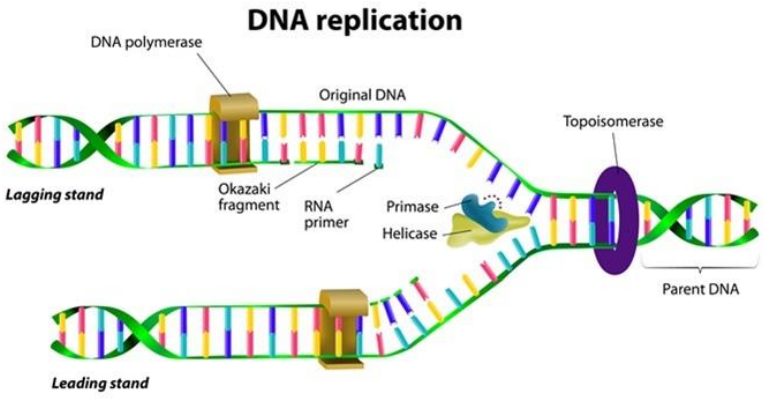
Unit 6, Topic 2: DNA Replication

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

1. *Identify the purpose of DNA replication*
2. *Identify and order the steps involved in DNA replication*
3. *Explain the purpose of molecules (enzymes) used in DNA replication*

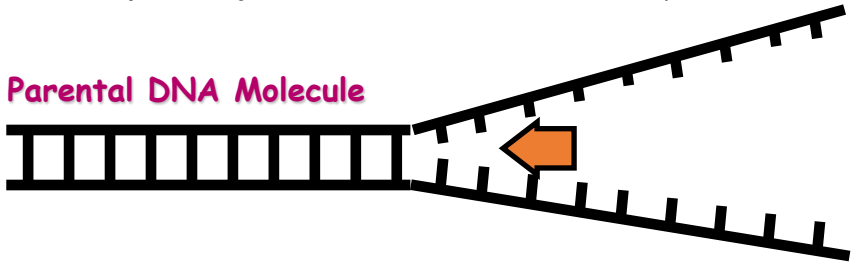


DNA REPLICATION

- Cells must copy their DNA before they do what? _____
  - Explain why: _____
    _____
- DNA is copied during the S or _____ phase of _____
- Where does DNA replication take place in eukaryotes? _____
  (remember, DNA cannot leave this location! It's too big)
- Replication of DNA begins at points called _____
- The two strands open at origins of replication forming Y-shaped areas called _____.

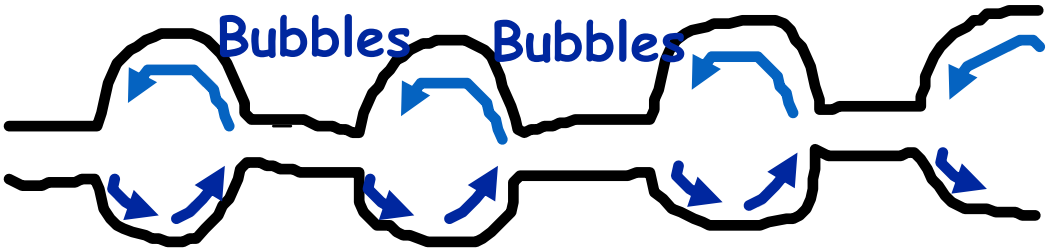
New strands of DNA grow here

- **Label** the ***replication fork*** and the ***5'*** and ***3'*** ends of each parent strand on the picture below.



Recall: Why are the 5' and 3' ends arranged like this?

- *As the two strands open at the origins of replication, replication _____ form.*
  - _____*(bacteria) have a single bubble.*
  - _____ *chromosomes have many bubbles.*



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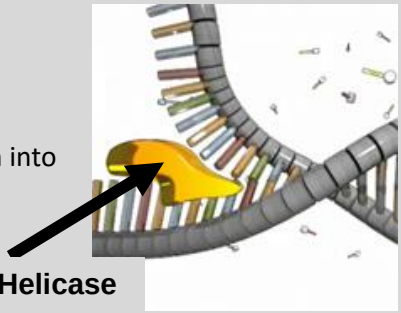
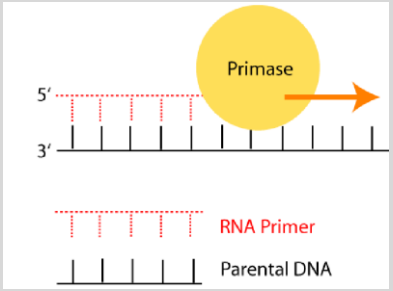
Steps of DNA Replication

- The enzyme _____ unwinds and separates the 2 DNA strands by breaking the weak _____ bonds between bases.
  - It "unzips" the double helix.
- _____ gathers _____ and brings them into the replication fork.
  - A _____ is created to start the new strand.

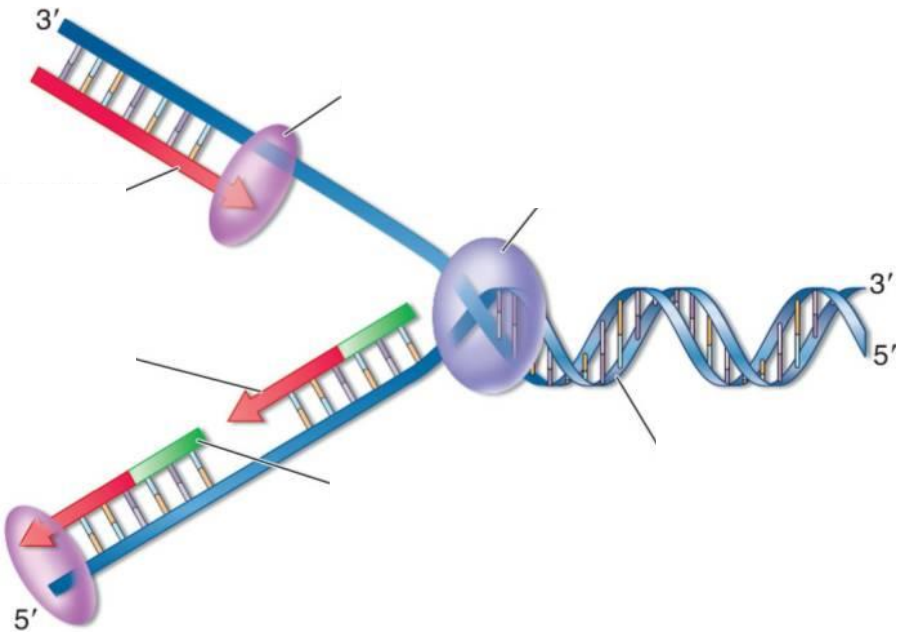


- The enzyme _____ matches free nucleotides with the correct base pairs on the _____ (parent) strands.



- The enzyme _____--_____ connects any "breaks" in the new strands, and the 2 identical strands _____ back together.
  - ***The Big Question****: Why are their breaks in the new strands at all?*
    - DNA polymerase can only add nucleotides to the _____ end of the DNA.
    - This causes the _____ to be built in a _____ to _____ direction.
    - The _____ is built into the replication fork.
    - The _____ is built in short sections in the _____direction (out of the fork). This causes the _____ in the strand.

- **Label** the ***leading strand, lagging strand, DNA polymerase, helicase, and primer*** in the picture below.



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Proofreading New DNA:

- DNA polymerase makes about _____ base pairing errors.
- _____ proofread and correct these mistakes → new error rate of _____.
    - **How does the DNA get damaged?**
        - _____ and _____ radiation damage the DNA in our body cells.
    - **Types of DNA repair**
        - _____ - when a repair enzyme removes damaged DNA.
        - _____ and _____ work together to replace and bond new nucleotides together.

[[*Language Target for Topic 2: I can explain the purpose of DNA replication; I can sequence the steps in DNA replication; I can provide the name of the enzyme involved in each step of DNA replication]]*

1. Number the steps of DNA replication in the correct order (1, 2, 3):

   _____ Daughter strands are formed using complementary base pairing.
   _____ DNA unwinds
   _____ The DNA of the daughter strands winds with together with its parent strand.

2. Why is DNA replication called "semi-conservative"?

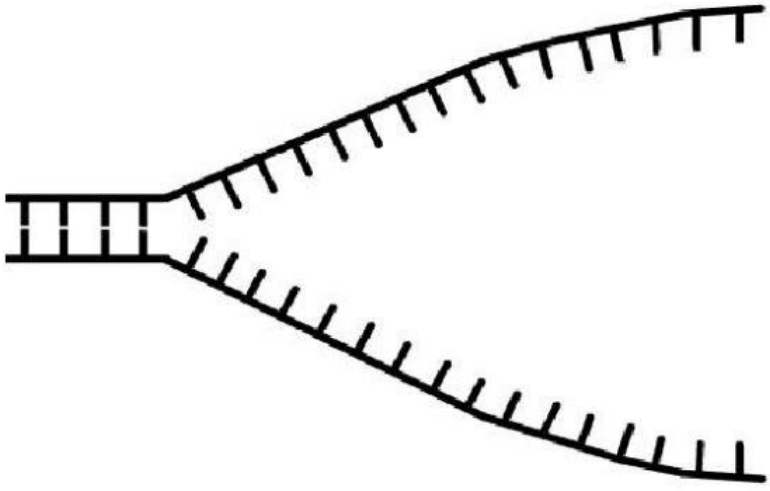
3. What enzyme unwinds or unzips the parent strand?

4. What enzyme connects the new bases to the old bases in the DNA template?

5. What enzyme connects the new nucleotides together and proofreads them?

Using the DNA provided, complete the following:

1. Label the 3' and 5' end of each strand (you decide which is which)
2. Label the replication fork
3. Draw and label helicase
4. Label the overall direction of DNA replication
5. Draw and label the leading strand
6. Draw and label DNA polymerase
7. Draw and label the lagging strands



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Unit 6, Topic 3: Protein Synthesis

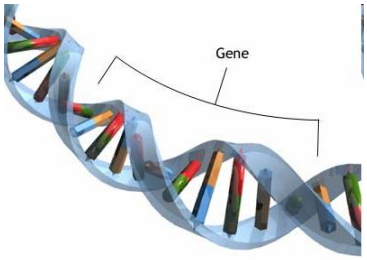
By the end of this topic, you should be able to…

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 _____ was the genetic material of the cell.
2. _____ are the workhorses of the cell…they do a lot of different jobs!
   - A)_____- immune system/defense
   - B) _____- hair/nails
   - C) _____ - enzymes
   - D) _____ - hemoglobin (carries oxygen in blood!)
   - E) _____ - muscle

How do our Cells Make Proteins?



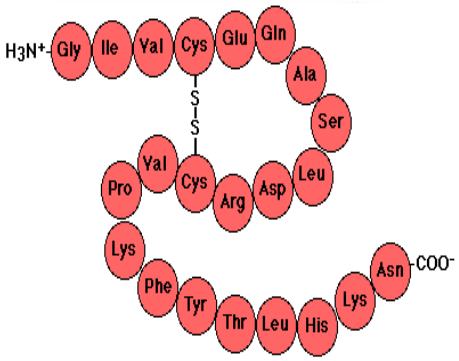
3. DNA contains _____, sections of nucleotide chains.

   Genes code for_____ (proteins).

   Polypeptides are _____ chains.

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

5. **The Solution:** A molecule called _____ carries the message. It's small enough to fit through the _____ in the nuclear membrane.



<u>Putting it together:</u>

- _____ is responsible for controlling the production of _____ in the cell, which is essential to life!
  - DNA→RNA→Proteins
- _____ contain several thousand _____, each with directions to make one _____

<u>Where are Proteins Produced?</u>

- Proteins are produced on _____!
- Found in two places:
  - Free floating in _____
  - Attached to _____
- How does information needed to build a protein gets delivered from the DNA to the ribosomes?
  - With the help of _____ in a process called _____

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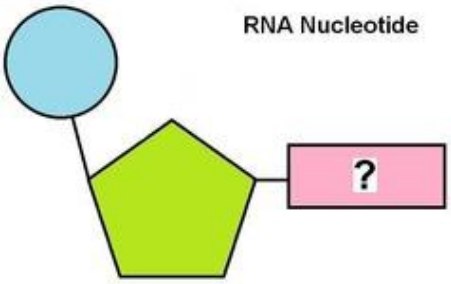
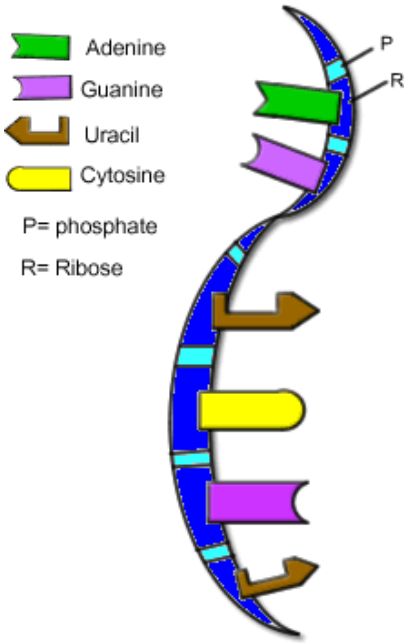
What is RNA?



- ***RNA*** stands for _____
- One subunit is called a _____
  - 1 5-carbon _____ (ribose)
  - 1 _____ group
  - 1 nitrogenous _____
- Three types of RNA: _____

A Closer Look at mRNA



- How is mRNA different from DNA?
  - _____ stranded
  - _____ and able to leave the _____
  - The sugar is _____
  - There is a different base
    - _____ (U) takes the place of _____ (T)
- The job of mRNA is to take directions for one gene and transport it to a _____ in the _____.
  - This is so a cell can begin assembling _____, the building blocks of _____!
  - It's sending a _____ on how to do the job!

Protein Synthesis

- ***Protein synthesis*** is a two stage process:
  _____
  - A _____ molecule (mRNA) carries instructions from DNA to ribosomes
    - DNA _____ leave the nucleus; _____ can!
    - _____ makes it possible for _____ to be assembled by _____ outside the nucleus

Protein Synthesis: Transcription

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

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

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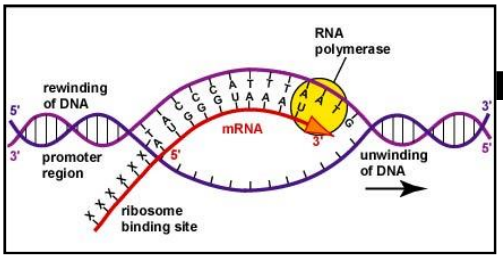
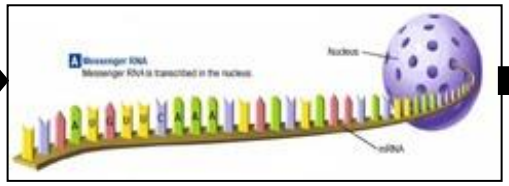
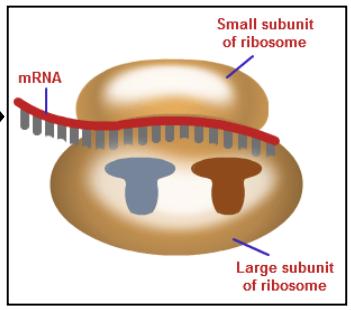
Think about it: What is happening in each photo below during transcription?







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

Protein Synthesis: Translation

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

Think about it: What amino acid is coded for?

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

First Letter	Second Letter				Third Letter
	U	C	A	G	
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

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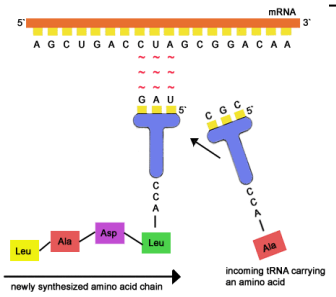
- ***Translation*** occurs in a _____ in ALL cells
- Uses all three forms of RNA (_____)
- DNA is not directly used!

Steps of Translation

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

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

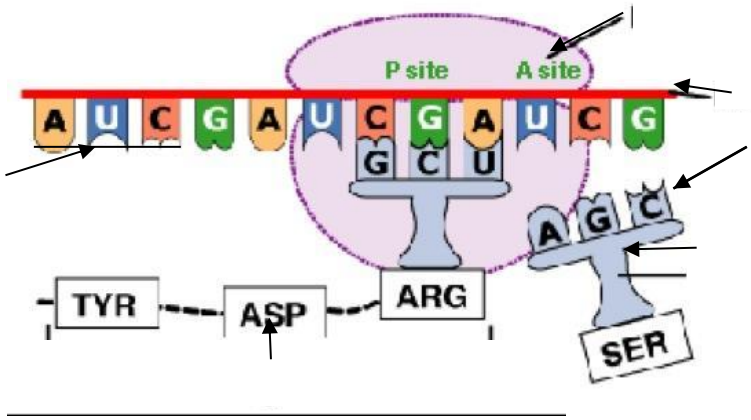
tRNA: A Closer Look



- 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"

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? _____
  - Now, transcribe the DNA to mRNA _____
  - What amino acid does the codon code for? (use chart) _____
  - What would the anticodon on tRNA read? _____

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- 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? _____

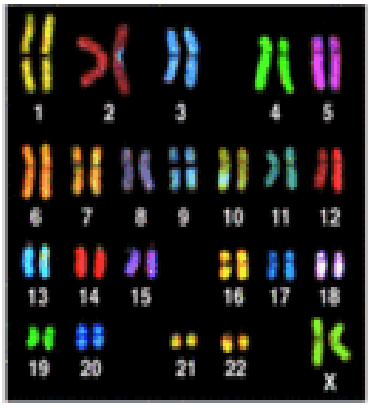
Mutations

- Changes to DNA are called _____
  - Change the _____
  - Change the _____
  - May change _____
  - May change _____

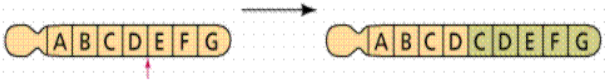
2 Main Types of Mutations:

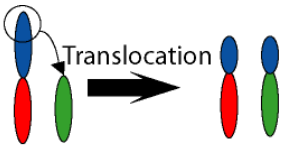
1.) Chromosomal Mutations- a mutation involving _____
2.) Gene Mutations- a mutation that involves a _____

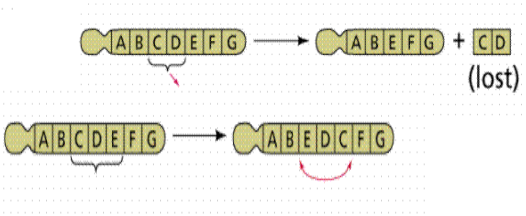
Chromosomes and Chromosomal Mutations:



- Humans have ____ 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 _____
- Chromosomal mutations occur when there is a change in _____ or _____ of chromosomes (LARGE SCALE)
- There are FIVE types of chromosomal mutations:
  1.) Deletion
  2.) Duplication
  3.) Inversion
  4.) Translocation
  5.) Nondisjunction







Most chromosomal mutations are:
_____

Gene Mutations:

- *Small scale:* _____ 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 _____ letter in the DNA!

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

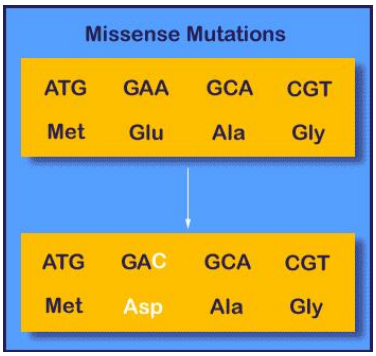
- ***Frame shift mutation***→ addition of a _____letter; or deletion of a letter!
  - Both of these _____ DNA so it changes how the codons are read
  - Big changes to protein

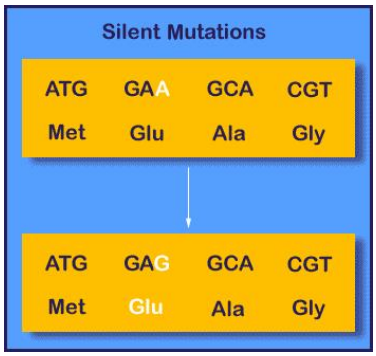
Point Mutations

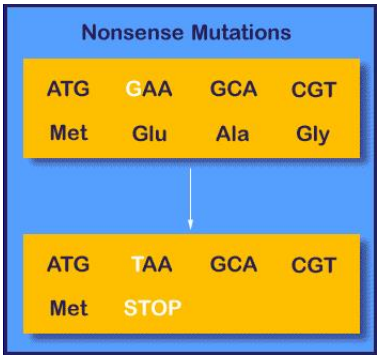
Missense mutation = _____ (Ex. Sickle Cell Anemia)

Silent mutation= _____

Nonsense mutation=_____

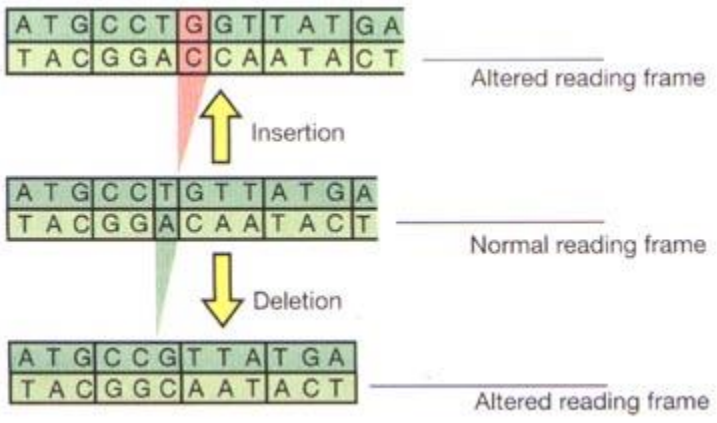






Frameshift Mutations

- _____ or _____ one or more bases
  - Change the meaning of the whole protein!
- ***Addition (insertion)***→ _____
- ***Deletion***→_____



[[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
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Read each term or phrase in the left-hand column of the following table. If the term or phrase applies to DNA, place 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		

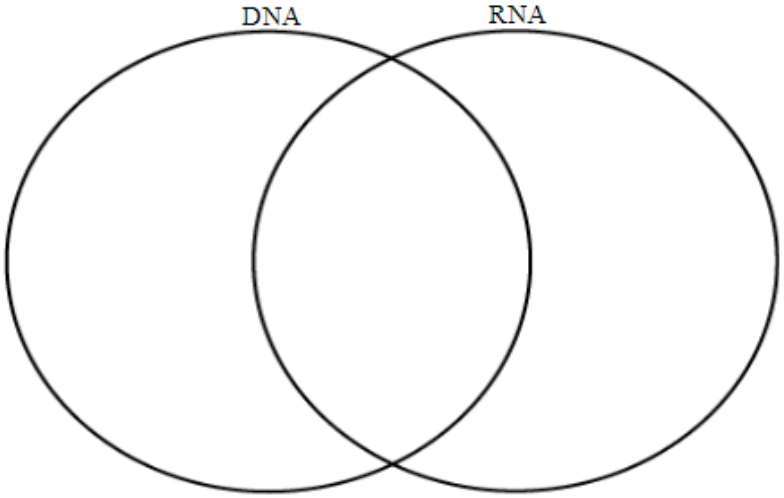
DNA: A T A C G A A A T C G C G A T C G C G G C G A T T C G G

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 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: _____

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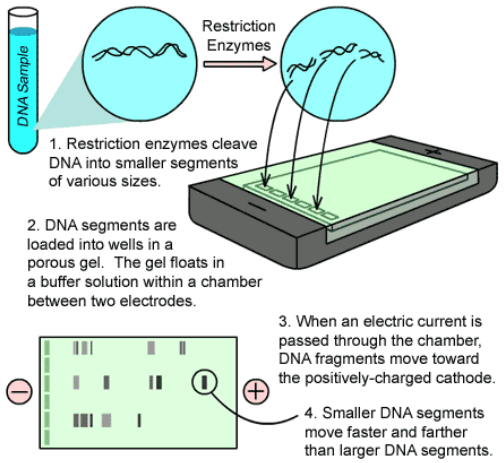
Unit 6, Topic 4: Biotechnology

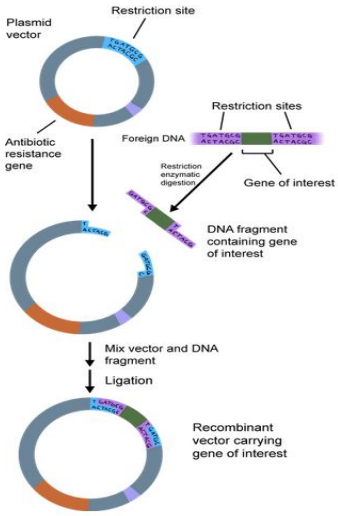
By the end of this topic, you should be able to…

1. *Describe the purpose and methods of gel electrophoresis and analyze electrophoresis results*
2. *Provide examples of the practical uses of biotechnology, including insulin production and cloning*
3. *Describe the purpose and methods of PCR (polymerase chain reactions)*

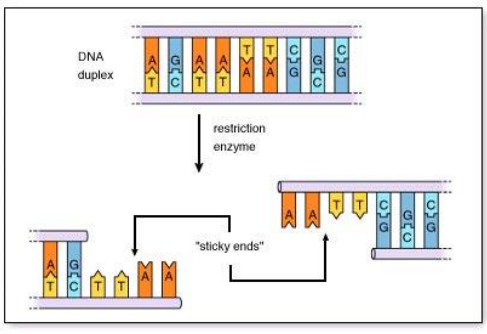
Figure S-2: Gel Electrophoresis



1. Genetic Engineering = _____
   a. With present technology and knowledge of DNA structure, we can extract, identify, modify, copy, and transfer DNA sequences!
   b. Genetic engineering allows scientists to create _____ traits within organisms to meet specific needs without relying on natural mutations.
2. PCR (polymerase chain reaction)
   a. PCR is the artificial _____ of DNA in a controlled environment.
   b. We use heat to separate the strands and special heat-resistant bacterial enzymes to speed up the process
3. Extracting DNA - (first step to genetically engineer an organism)
   a. DNA extraction is relatively easy to do from the cells of plants and animals! We can even do it in the classroom!
   b. Once you have extracted the DNA, you can _____ _____ it in helpful ways

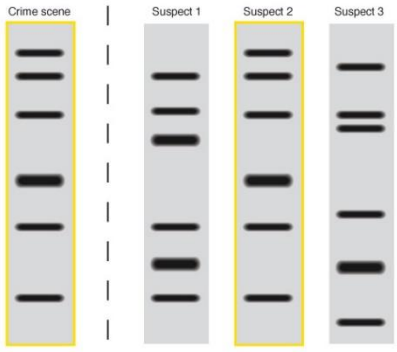


4. Cutting DNA – (second step)
   a. Remember: DNA is a very long molecule
   b. In order to make working with DNA more manageable, scientists use _____ to cut DNA into fragments known as restrictive fragments.
   c. These restrictive enzymes are chemicals that bind to and make cuts at specific sequences in DNA.
5. Separating DNA (third step)
   a. Once DNA is cut into fragments, scientists select only those sequences that code for particular traits.
   b. Gel electrophoresis is one technique that is used to sort DNA sequences by _____, which can be read and analyzed.
   c. Once it is sorted, scientists can…
      i. study individual genes on the DNA
      ii. obtain a segment of DNA to copy using a technique called PCR (polymerase chain reaction)
      iii. help locate genetic diseases to potentially eliminate them
6. Changing DNA (fourth step)
   a. Like Frederick Griffith's early bacterial transformation, scientists are able to take segments of one organism's DNA and place it into the _____ of other organisms
   b. Recombinant-DNA Technology is the type of genetic engineering where DNA from two are more different sources is joined (resulting in what are called _____ organisms)



Name: _____
DNA/RNA/Protein Synthesis

7. Steps in Transforming Bacteria
   a. Recombine DNA-restriction enzymes like *Eco*RI cut the DNA into fragments to prepare them for recombination
   b. Transport DNA-a scientist has to insert recombinant DNA pieces into the host cell (into plasmids, or circular DNA, in bacterial cells)
   c. Transfer DNA- When the host cell divides (by binary fusion), it also makes a copy of the newly transformed plasmid (called a recombinant plasmid)
   d. Genetic markers, such as those for antibiotic resistance, inserted into the plasmid along with the specific desired gene allow scientists to pinpoint transgenic cells
8. Uses of Recombinant DNA Technology
   a. Advances in medicine
      i. Transgenic animals and plants that provide _____
      ii. Transgenic animals used as test subjects
      iii. Insulin or Human Growth Hormone production by bacteria
      iv. Human Genome Project & Gene Therapy
   b. Agriculture
      i. Genetically modified plants and animals (their cells don't accept foreign DNA very well so you must infect plant and animal cells with bacteria containing recombinant plasmids)
   c. Personal identification
      i. DNA fingerprinting
      ii. Paternity testing
      iii. Forensic science



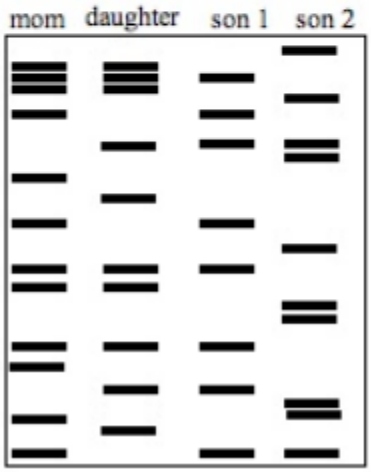
   d. Cloning
      i. When humans clone, they use a single cell of an adult organism to grow a new genetically identical individual
      ii. They Inserts the nuclei from the blastula stage (hallow ball of cells after several divisions of a zygote) of an embryo into an adult cell → Ex. Dolly the sheep
9. Human Genome Project
   a. The goal was to determine the sequence of nitrogen bases in human DNA. An entire set of DNA from a body cell is considered that organism's genome.
   b. There are _____ in the human genome and approximately 25,000 genes.
   c. NIH is striving to cut the cost of sequencing an individual's genome to $1,000 or less. Having one's complete genome sequence will make it easier to diagnose, manage and treat many diseases.

[[*Language Target for Topic 4: I can interpret gel electrophoresis results through writing; I can compose a written list of the practical uses of biotechnology; I can explain the purpose and methods of polymerase chain reaction]]*

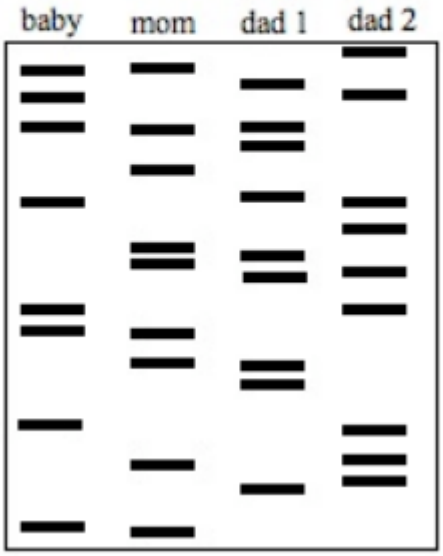
OPHS Biology
Unit 6 Notes

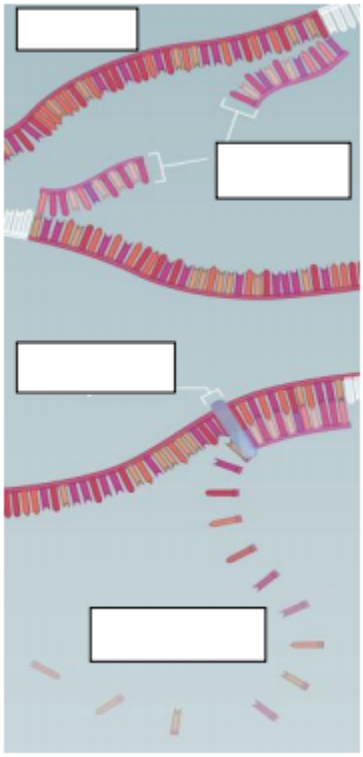
Name: _____
DNA/RNA/Protein Synthesis

The millionaire, Mr. Big, has just died. He has left behind a wife, daughter and a large inheritance. The news of his death has brought forth 2 men who claim to be the long lost son of Mr. & Mrs. Big. Before Mr. & Mrs. Big were married they had an illegitimate child and had placed him up for adoption. They had tried to find him after they became wealthy but had no luck in locating him. A DNA sample was taken from Mrs. Big, the Big daughter and the two men who claim to be the long lost son. Which, if any, of the men are telling the truth? _____



Mrs. Smith has a baby named Tyra. She believes one of two men can be the father of her child. A paternity test is done and the results are shown above. Which of the 2 men are baby Tyra's father? _____





Match the following terms with their definitions and label each component of the PCR mixture in the diagram (use the letters A-D):

_____DNA polymerase

_____Primers

_____ Nucleotides

_____Genomic DNA template

A. DNA that contains the target sequence that will be replicated using PCR.

B. An enzyme that copies the DNA sequence.

C. A mixture of 4 nucleotides (A,G,C, and T) that will be polymerized into the replicated DNA sequence.

D. A short DNA sequence that allows the enzyme to bind and initiate polymerization.