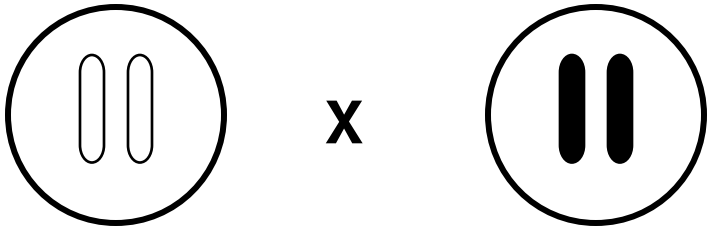
Genetics: Review of Mendelian Genetics

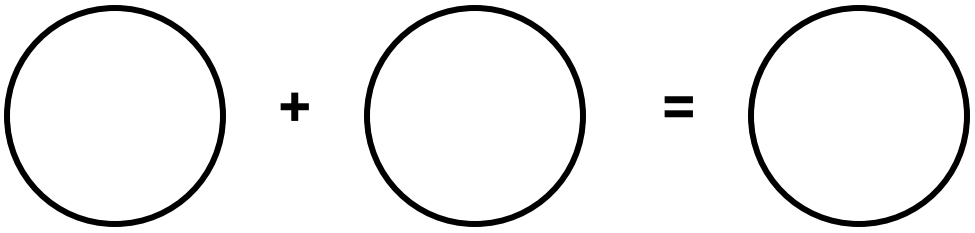
Directions: Below is a diagram of a man and a woman who have a baby. For the sake of simplicity there is only one pair of chromosomes.

Pure Brown Eyes **Pure Blue Eyes**



2N = _____ **2N = _____**

1. Draw and label the genetic content of the gametes and zygote below that result from the parents above.



Sperm **Egg** **Zygote**

N = _____ **N = _____** **2N = _____**

2. The following questions are based on the diagrams above.

a. What is the trait? _____

b. What are the two different expressions of the trait? _____

c. What is a gene?

d. How many genes for the trait? _____ Explain.

e. Define pure or homozygous trait.

f. Define hybrid or heterozygous trait.

g. What is the dominant gene? _____ Explain.

h. What is the recessive gene? _____ Explain.

i. Write a genetic key in terms of the letters for the genes:

Brown eye gene = _____ Blue eye gene = _____

j. Define:

Genotype –

Phenotype –

k. Write the genotypes of:

Pure Brown Eyes = _____

Hybrid (heterozygous) Brown Eyes = _____

Pure Blue Eyes = _____

3. Identify and explain the Mendelian principle that is illustrated in the above inheritance of eye color.

Molecular Genetics

I. Molecular Composition

A. Define:

Molecule:

B. What is the name of the molecules that makes up the chemical composition of the gene?

D_____ N_____ A_____

C. Read the paragraph below and then answer the questions. Number each line and indicate the line for each answer.

DNA is a macromolecule or polymer composed of simpler molecules. Remember that in the past study of biochemistry there were other polymers such as carbohydrates, lipids, and proteins which are also composed of simpler molecules. One of the molecules is a 5 carbon deoxyribose sugar molecule or "S". The sugar has a carbon on which one of the oxygen atoms has been removed. The prefix de- means to take away and since an oxygen tom has been taken away, the word deoxy means to take away oxygen. There is a phosphate molecule or "P" which is made of the atoms phosphorus, oxygen and hydrogen. And the third molecule that is part of DNA is an organic nitrogenous base or "B" which contains C, H, O, and N.

These three molecules, deoxyribose sugar, phosphate, and the organic nitrogen base form the basic unit called a NUCLEOTIDE. One phosphate (P), one sugar (S), and one organic base (B) = one nucleotide. DNA is a nucleic acid composed of units of nucleotides which are composed of P, S, and B chemically united.

1. List the three small molecules that make up the polymer DNA.

2. Define: Polymer –

3. Explain the word, deoxy.

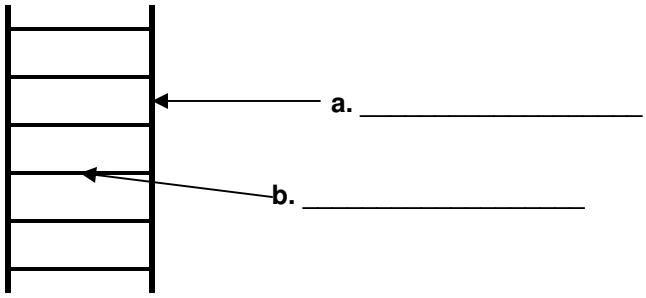
4. What is a nucleotide?

5. What is one nucleotide made up of?

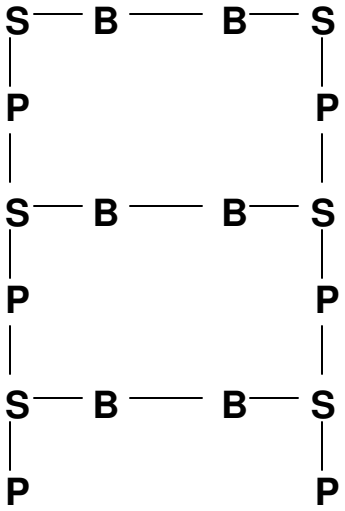
6. List the number and kind of molecules that will be found in 2 nucleotides.

7. Define: Nucleic Acid –

D. Study the diagram below. Describe its structure and label parts a and b.



E. Now study the diagram below and describe the CHEMICAL STRUCTURE of the macromolecule DNA. Note that each letter is a molecule and that each dash is a chemical bond.



1. The uprights of the ladder are composed of:

2. The rungs of the ladder are composed of:

3. How many nucleotides are there in this polymer?

F. Arrange these pieces of the puzzle to make them "fit into one another" or are chemically bonded. These are complementary molecules. Recall the Lock-n-Key hypothesis of enzyme action.

1. 

2. 

3. 

4. 

G. The following are the 4 different kinds of organic nitrogen bases that are found in DNA.

Adenine = A = 

Thymine = T = 

Guanine = G = 

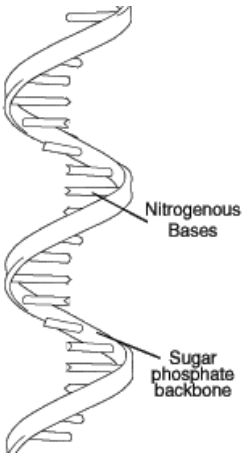
Cytosine = C = 

H. Draw and label the complementary base pairings.

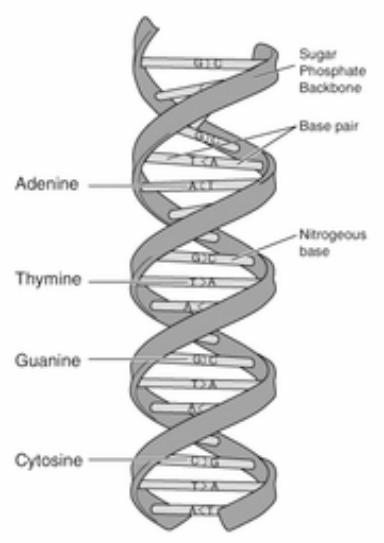
I. Recall that a nucleotide = deoxyribose sugar + phosphate + organic nitrogen base. In terms of the symbols S, P, A, T, C, and G list the 4 different kinds of nucleotides.

J. Now draw the upright ladder to represent DNA. Recall that the uprights consist of alternating S and P and the rungs of the ladder consist of complementary base pairs, A – T, and C – G which are to be arranged randomly.

K. Below is a diagram of a single helix. It is analogous to a rope wound around a pole. Make your own drawing of a single helix.



L. Below is a diagram of a double helix. DNA is double helix. Make your own drawing of a double helix DNA Molecule.



M. Describe the term "Double Helix".

N. Describe what is molecular genetics.

Geometric Symbols for DNA

I. Symbols

A. Directions: Below are the symbols for each molecule of the macromolecule DNA.

KEY for Nucleotide Construction

Sugar = 

Adenine = 

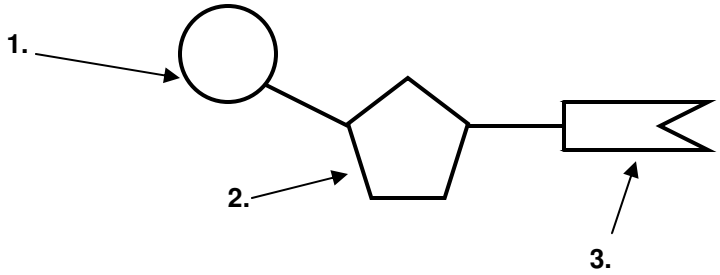
Cytosine = 

Phosphate = 

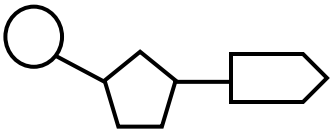
Thymine = 

Guanine = 

B. Recall that one nucleotide = one phosphate, one sugar and one organic base. The three molecules are chemically united in the following way. 1 = phosphate, 2 = sugar, 3 = organic nitrogen base.



Draw each different symbolic nucleotide below. The first one has been done for you.

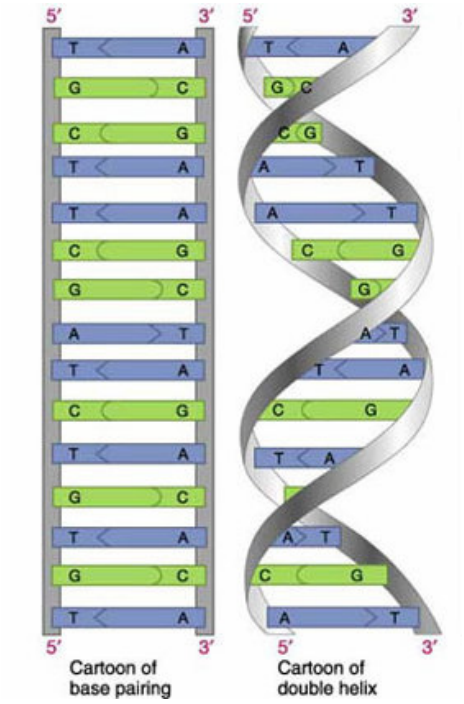
Nitrogen Base	Drawing of Nucleotide
Adenine	
Thymine	
Guanine	
Cytosine	

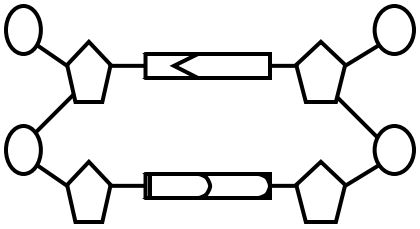
III. The Composition and Structure of DNA

A. Draw a sketch of an untwisted ladder with 2 uprights and 8 rungs.

B. Redraw the sketch above but substitute the letter symbols S, P, and the bases A, T, G, and C.

C. Continue the drawing below using the geometric symbols from the previous page.





How is a Chromosome and Genes like a loaf of bread?

Diagram 1 – Represents a loaf of bread

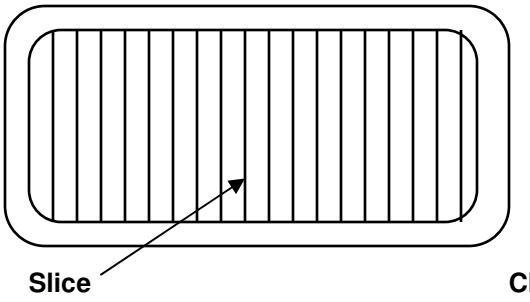
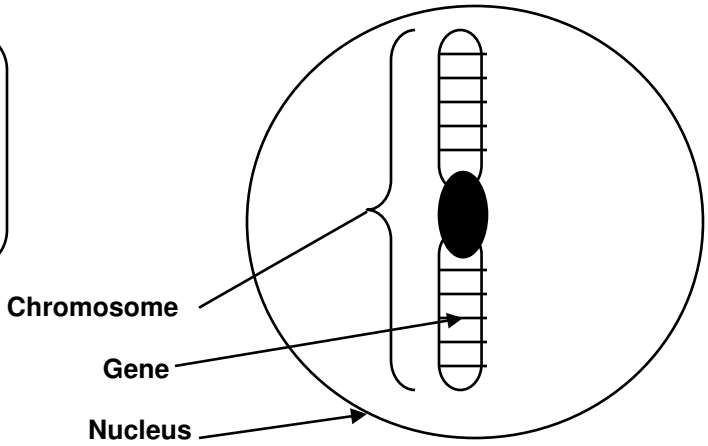


Diagram 2 – Represents a chromosome



<u>Directions</u>: Use diagrams 1 and 2 to complete the chart below.

Characteristic	Bread	Chromosome
Location		
Identify what is inside the bag/nucleus		
Broken down into		
Organic Building Blocks		
Contains the Elements		

Describe how a chromosome is like a loaf of bread.

First Function of DNA = Replication

I. Definition

A. Replication –

B. Identify the two types of cell reproduction in which replication occurs.

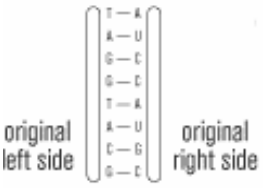
1. _____ **2.** _____

C. Explain why replication must occur.

II. Consequence and Sequence

Directions: Identify each sequence and explain its consequence.

Sequence **Consequence**



1

1. _____

_____

_____

2

2. _____

_____

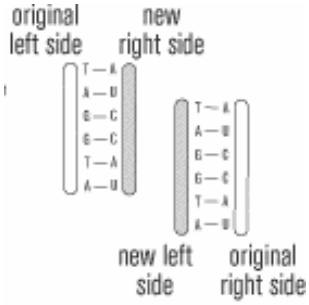
_____

3

3. _____

_____

_____



4

4. _____

_____

_____

The Synthesis of a Complementary Strand

I. Complementary Bases

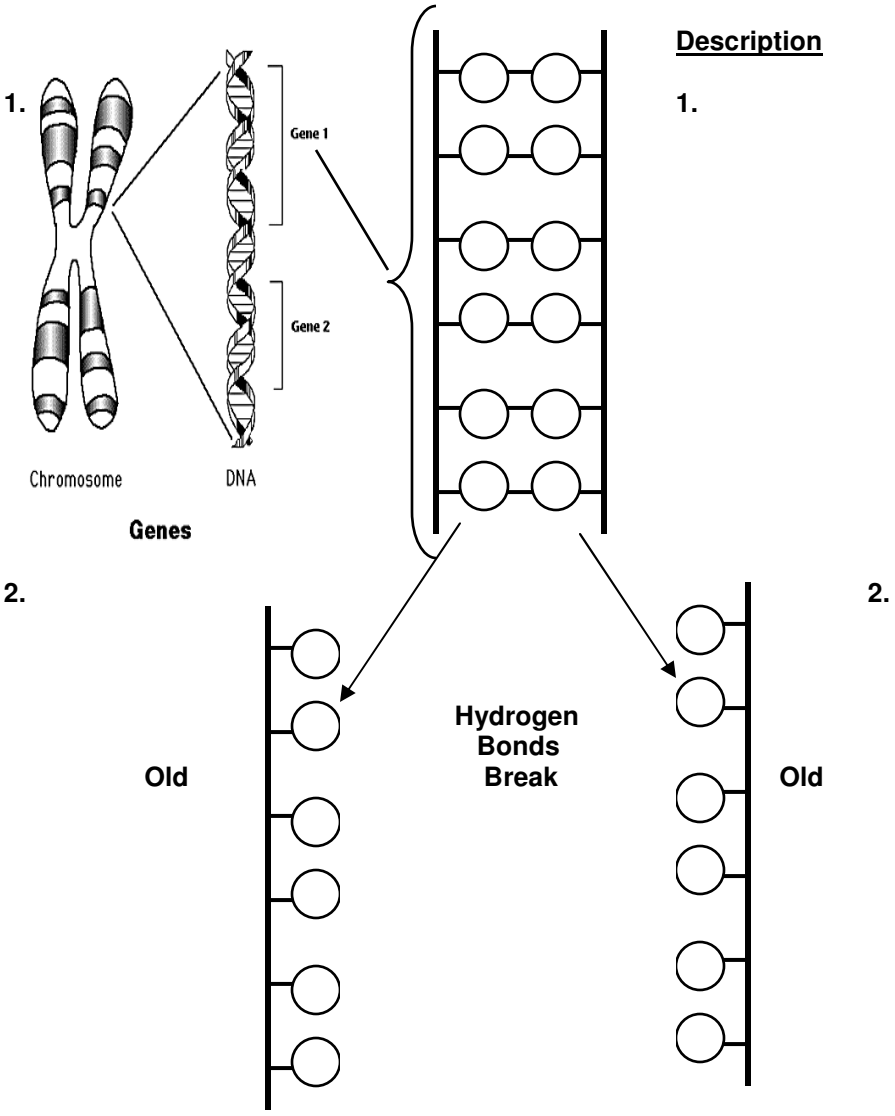
Define with examples the term: Complementary Bases

II. Synthesis

A. Define: Synthesis –

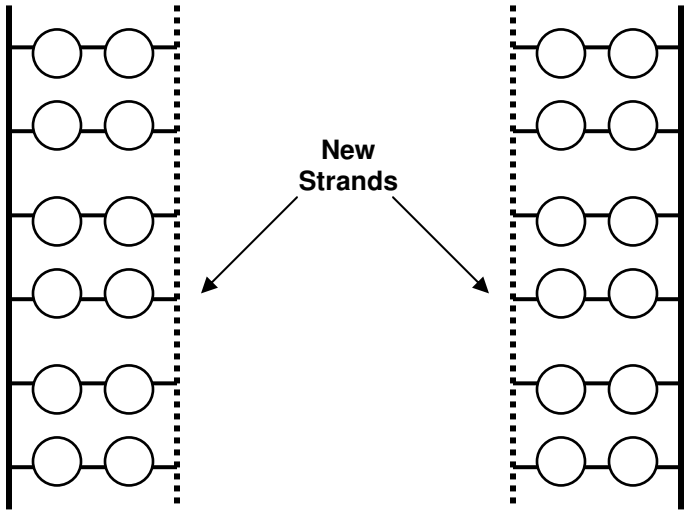
B. Explain the source of the nucleotides for synthesis.

III. Synthesis of new complementary strands.



Description

3.

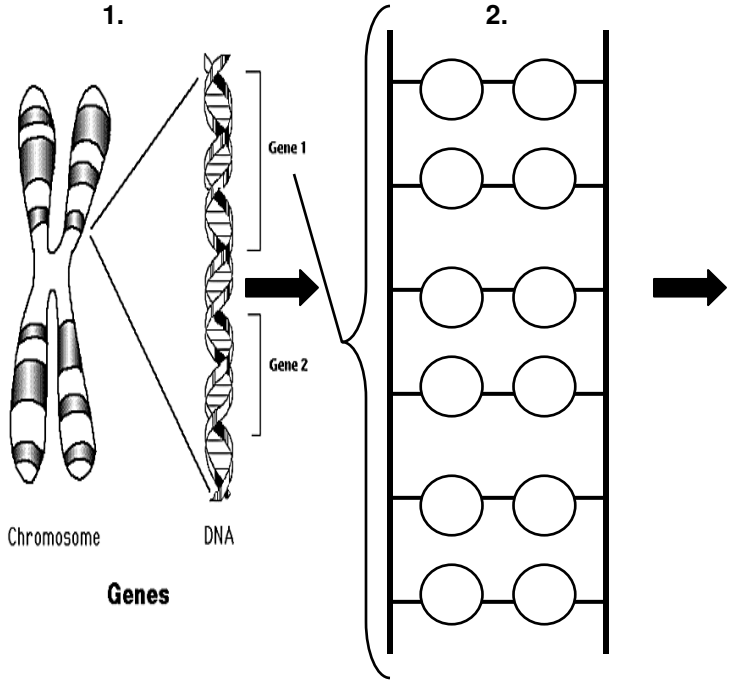


3.

The Replication of a Gene

Directions: Create a gene for eye color which consists of 12 nucleotides. Go through the sequence of replication and draw the replication of a gene.

1. **2.** **3.**

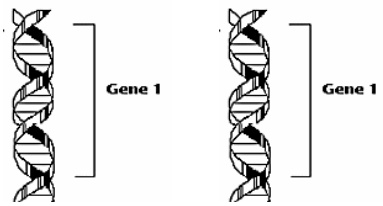


1. This is your DNA Molecule

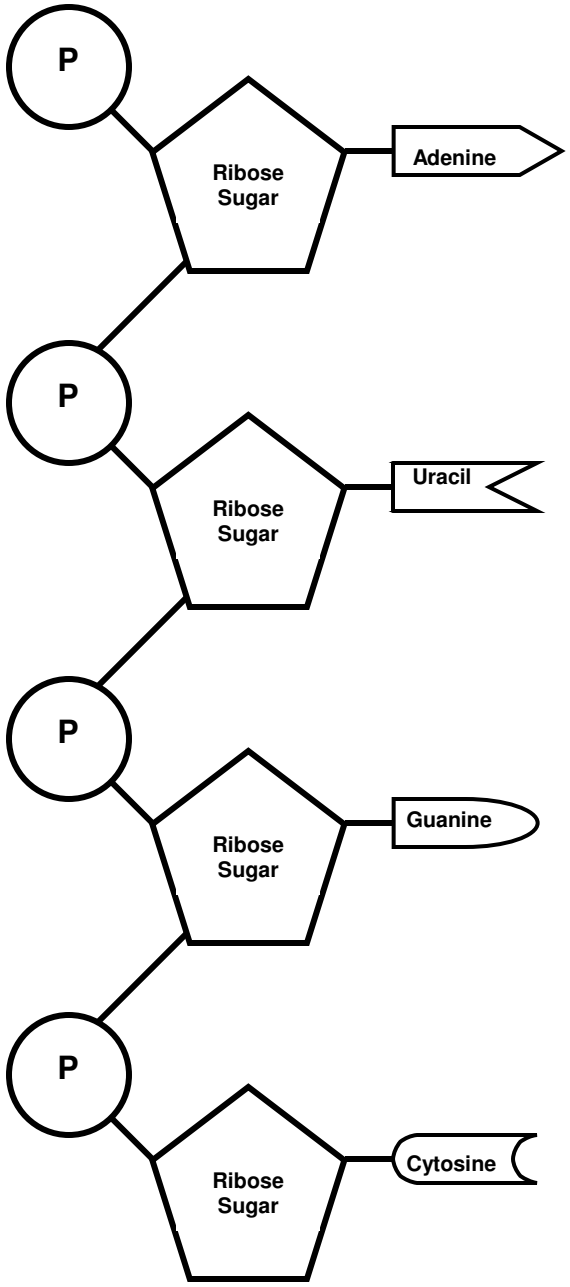
2. Create your DNA molecule for your gene

3. Draw Replication

4. Two new DNA molecules become double helices



Structure and Composition of RNA



Structure

Composition

R_____N_____A_____

Comparing DNA and RNA

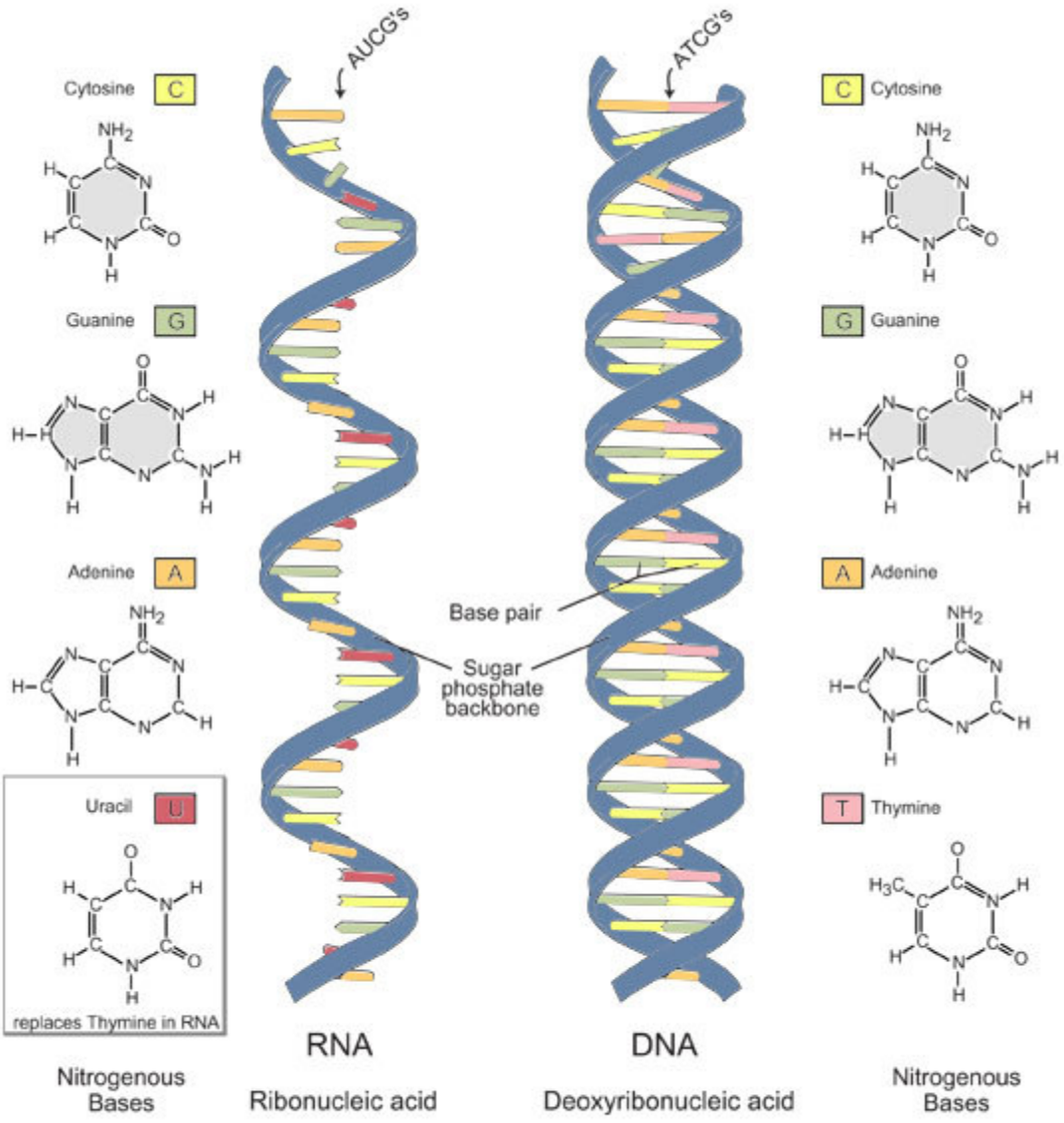


Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion//DIR/VIP/Glossary/Illustration/rna.shtml.

<u>Directions</u>: Compare RNA and DNA by completing the chart below.

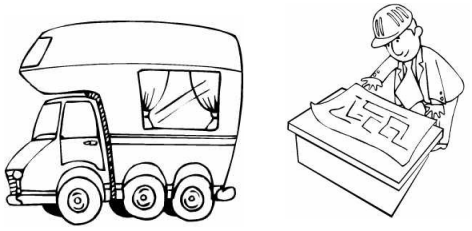
Characteristic	DNA	RNA	Similar/Different
Number of Strands			
Components			
Type of Sugar			
Bases			

Second Function of DNA = Protein Synthesis

I. Analogy in the construction of a wall.

Directions: Study the sequence of the diagrams below and for each diagram, identify and describe the organelle/molecule and its function.

1. Trailer (nucleus) – contains the blueprints (DNA) for the construction of the wall.



2. Foreman (messenger RNA or mRNA) copies the blueprints and brings the information to the construction site.

3. Construction Site (ribosome) – place where wall (protein) is to be built.

4. Workers (transfer RNA or tRNA) bring bricks (amino acids) to the construction site.

5. Wall (protein) is built according to specific information in blueprints.

6. Wall has the function of support. Proteins have varied functions in cells.

Second Function of DNA = Protein Synthesis

I. Analogy in the construction of a wall.

Directions: Study the sequence of the diagrams below and for each diagram, identify and describe the organelle/molecule and its function.

1. DNA - _____

_____

_____

2. mRNA - _____

_____

_____

3. Ribosome - _____

_____

_____

4. tRNA - _____

_____

_____

5. Amino Acids - _____

_____

_____

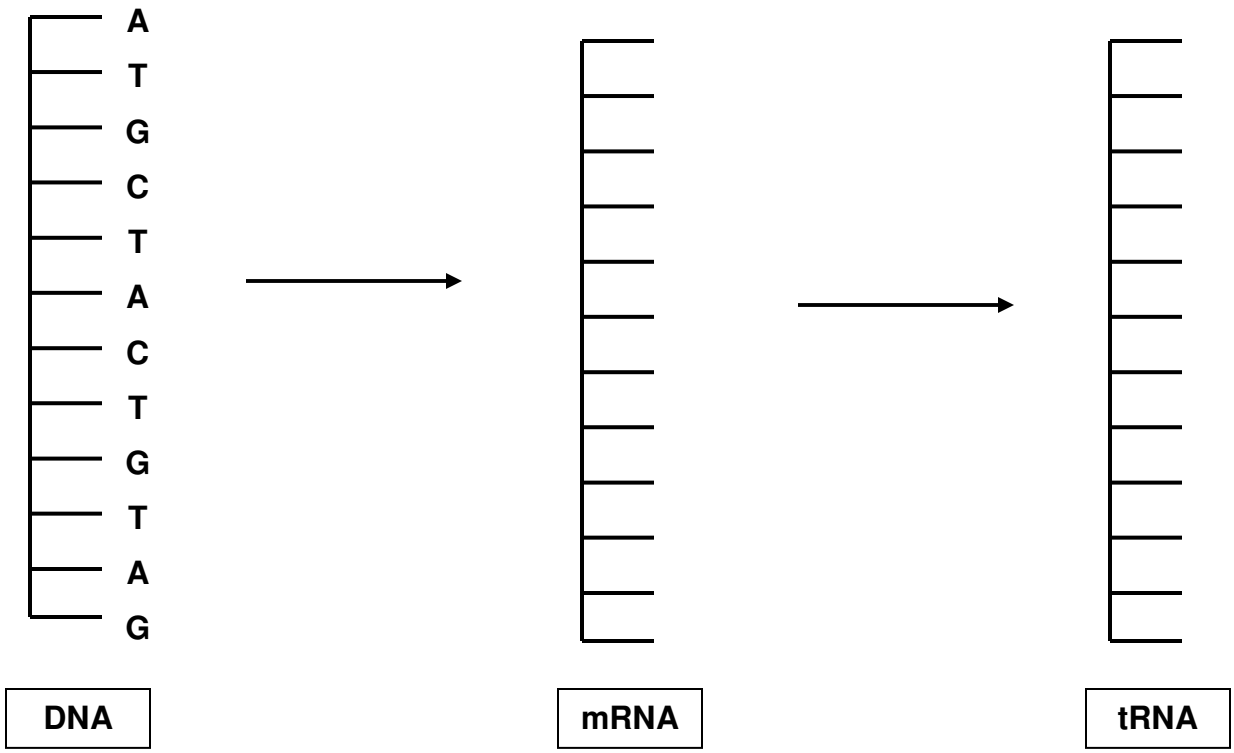
6. Protein - _____

_____

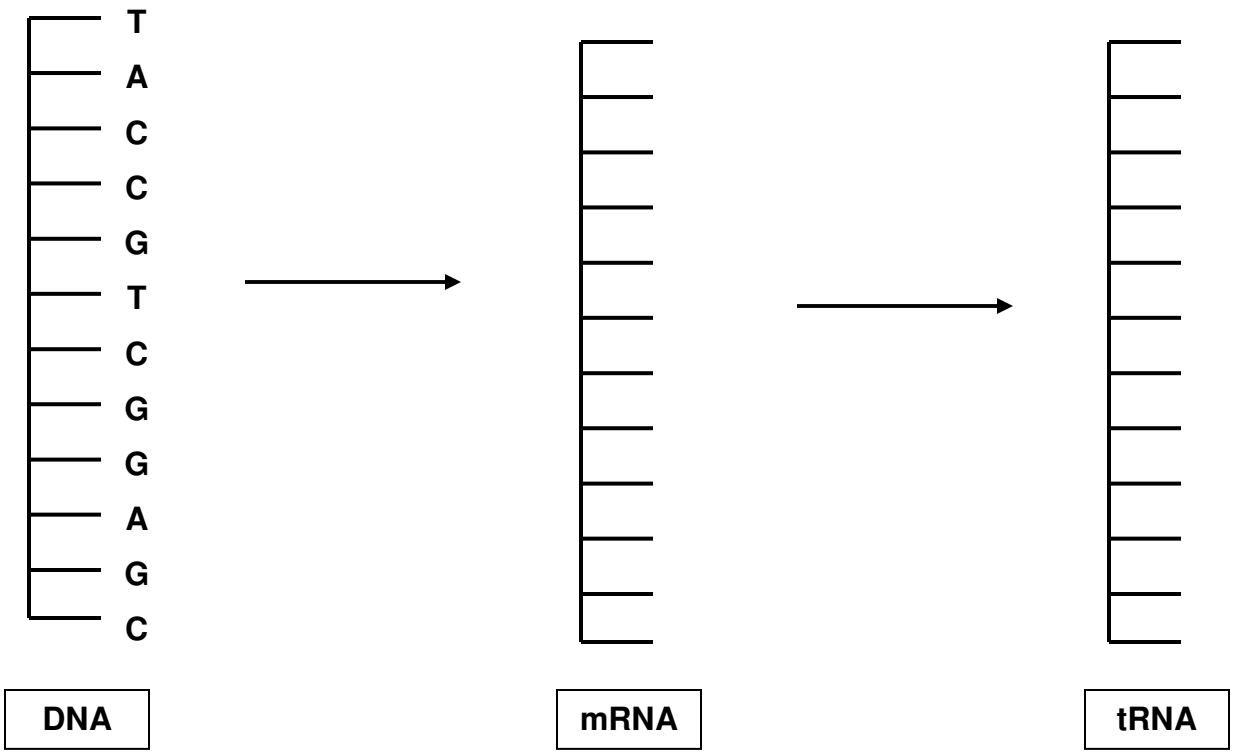
_____

Directions: Using the DNA strand as a template, match the appropriate base with its complement on mRNA and tRNA.

1.



2.



The Genetic Code

I. The Analogy of the Morse Code

A. Creating the code

Directions: With the aid of a dot ● and a dash ——— create a code for each of the letters of the alphabet.

Letter	Code
A	
B	
C	
Etc.	

1. How many different codes are needed? Explain.

2. Assume that you have created all the codes, write your code for a three letter word.

Letter	Code

3. If two people selected the word tea what must be true of their codes? Explain.

B. Creation of Meaning

1. Can the same codes be used to create different words? Explain what determines the meaning of the words?

2. Explain how with 26 different letters (codes) there are thousands of different words.

II. The Genetic Code

A. Location of the code in the DNA molecule

Directions: Compare the two segments of two different DNA molecules.

1. **Explain where in the structure of the DNA molecule, does the genetic code exist.**

2. **The second function of DNA is Protein Synthesis. Proteins are polymers composed of amino acids. If there are 20 different amino acids, what is the minimum number of codes?**

B. Creating the Code

Directions: Below are the names of several different amino acids. With the aid of the 4 different bases create a code for each different amino acid.

Amino Acid	Base Code
Alanine	
Asparagine	
Lysine	
Glycine	
Phenylalanine	
Threonine	

1. **Can one base code for the 20 different amino acid? Explain.**

2. **Can any order of two bases code for different amino acids?**

3. **Can three bases in any order code for different amino acids? Explain.**

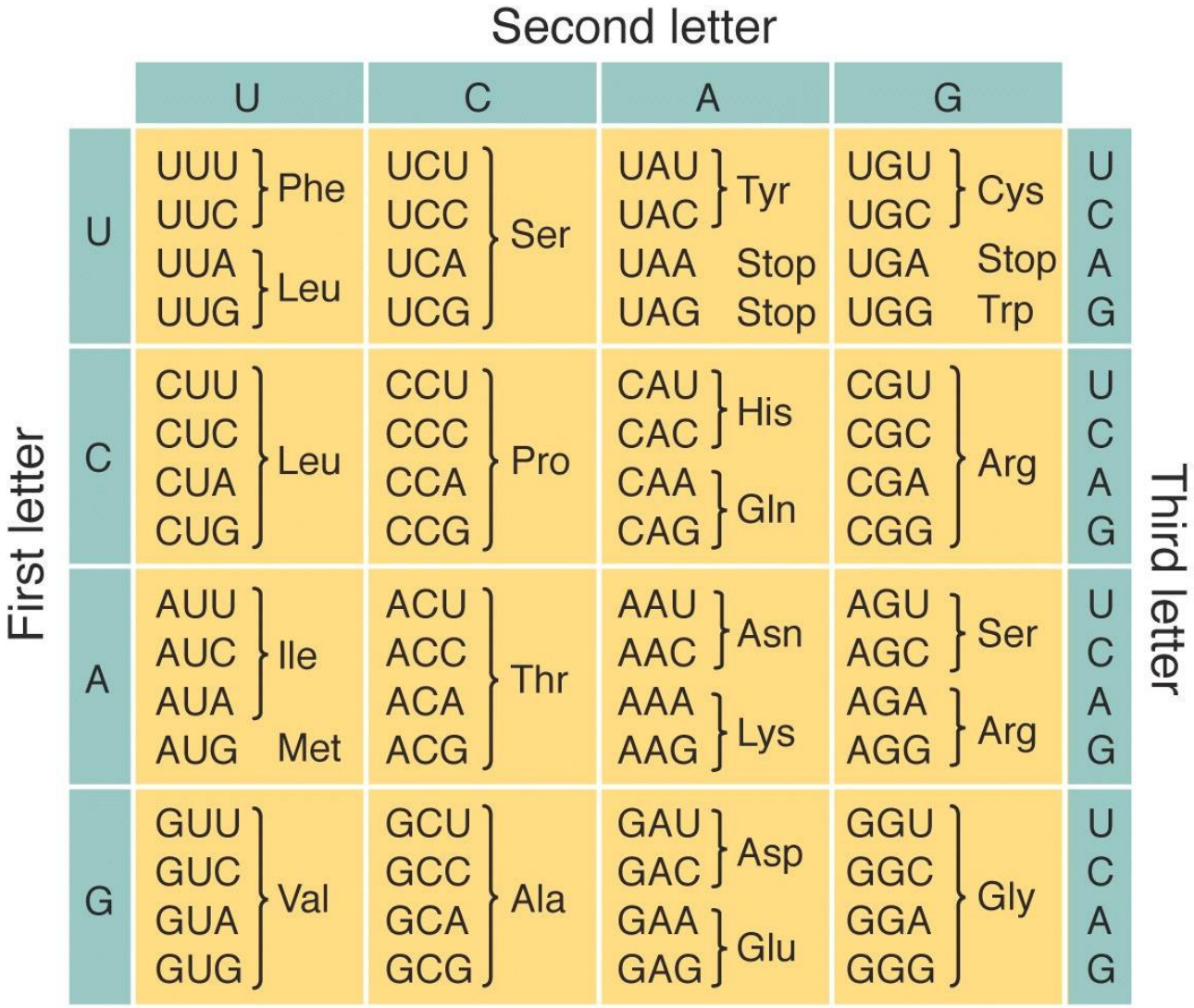
Define:

Triplet Code –

C. Cracking the Genetic Code

To determine the codes researchers used the bases on the mRNA. Recall that these bases on mRNA are complementary to the DNA. Hence, if the code on the mRNA is UUU, on the DNA it is AAA. Below is a chart of the mRNA codes (codons) for each different amino acid. To read the chart below:

1. Locate amino acid – example: Phenylalanine
2. Go to the column to the left, "First Base in Codon" and locate U for uracil.
3. Go directly above the name of the amino acid and locate U for the "second Base in Codon".
4. Go to the last column and locate U for the "Third base in the Codon", hence the triplet code for Phenylalanine is UUU.



1. Identify the codes for the following amino acids:

Tyrosine _____ Methionine _____ Trytophan _____

2. Identify the amino acid for the following codes:

ACU _____ GAC _____ CGC _____

3. Identify the sequence of nRNA and DNA codes for the following:

Valine – Serine – Lysine – Glysine

mRNA _____

DNA _____

4. Identify the sequence of amino acids for the following mRNA codes:

AUU – CCU – GGG – UGU

_____

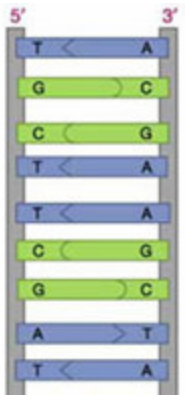
5. Identify the sequence of amino acids for the following mRNA codes:

ACG – CUA – CCC – AAA

_____

Protein Synthesis with Triplet Code

Directions: List the triplet codes in sequence on DNA, mRNA, and the tRNA. In step #5 draw in linear sequence the shapes of the amino acid that form the protein.



5'

1 - DNA Template

2 - mRNA

Ribosome

UUU

tRNA

UGC

tRNA

3 - mRNA

4 - tRNA

UUC

tRNA

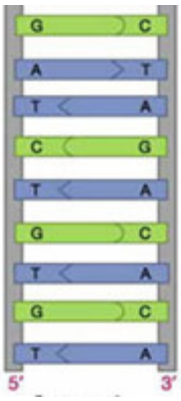
GAU

tRNA

5 – Build the Protein

The Synthesis of Your Protein

Directions: List the triplet codes in sequence on DNA, mRNA, and the tRNA. In step #5 draw in linear sequence the shapes of the amino acid that form the protein.



5'

1 - DNA Template

2 - mRNA

Ribosome

3 - mRNA _____

4 - tRNA _____

5 – Build the Protein _____

GAU

tRNA

ASP

CUG

tRNA

Leu

UGU

tRNA

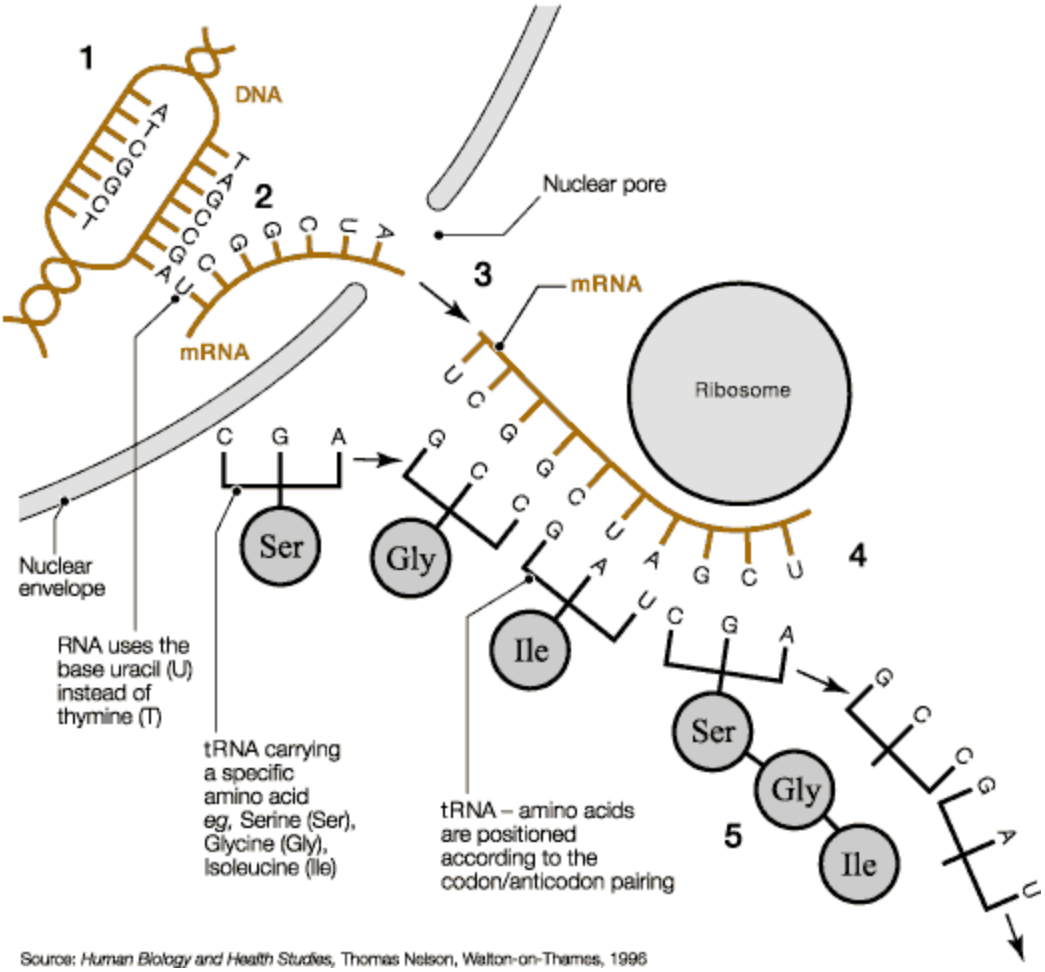
CYS

GGG

tRNA

GLY

Protein Synthesis



Source: *Human Biology and Health Studies*, Thomas Nelson, Walton-on-Thames, 1996

1. The DNA double helix unwinds to expose a sequence of nitrogenous bases.

2. A copy of one of the strands is made in a process known as transcription. The copy is made of messenger ribonucleic acid (mRNA) which, following transcription, travels out of the nucleus into the main body of the cell, where protein synthesis occurs.

3. The mRNA couples with the protein synthesis apparatus (the ribosome). Another type of RNA, known as transfer RNA (tRNA), brings free amino acids to the ribosome.

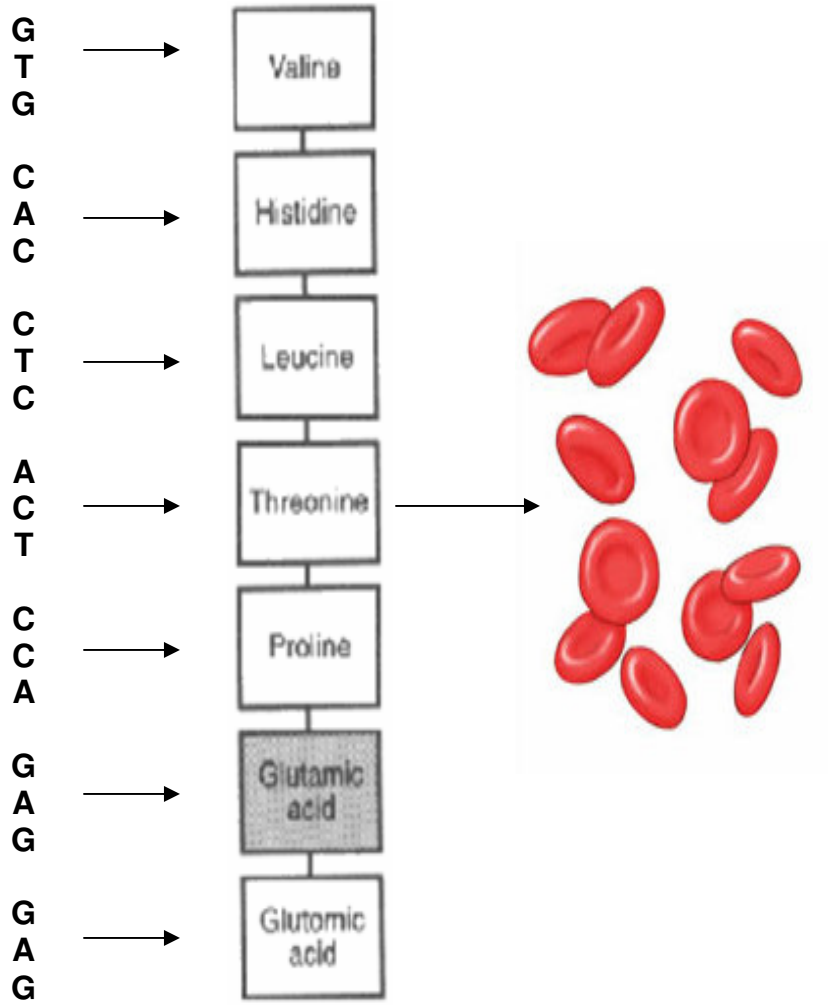
4. The anticodon present on the tRNA recognises the codon present on the mRNA, and the ribosome adds the amino acid to the growing chain of linked amino acids (polypeptides), cleaving it away from the tRNA. This process is known as translation.

5. As the polypeptide chain grows, it folds to form a protein.

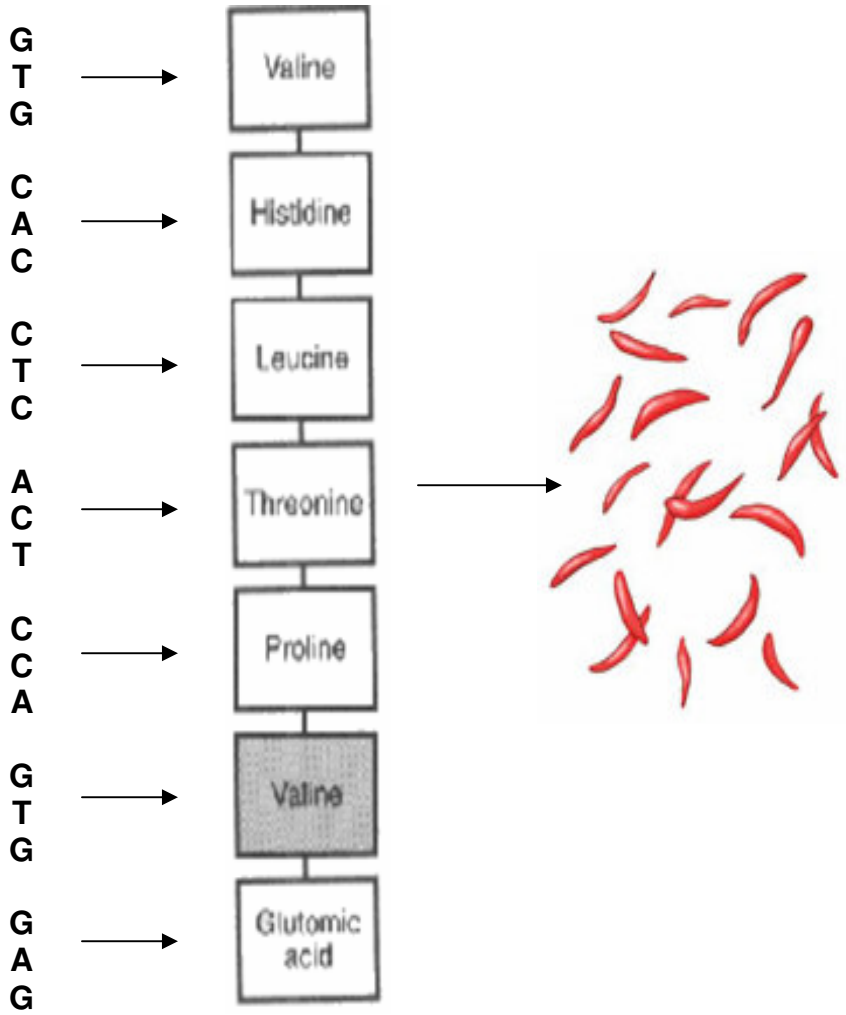
A Gene Mutation

Directions: **Study the diagrams of an abbreviated sequence of protein synthesis that results in two different traits, normal blood cells and sickle blood cells. Answer the questions below.**

1. Normal Red Blood Cells



2. Sickle Cell Anemia



Answer the following questions based on the diagrams above.

1. Study the triplet codes in DNA #1 and DNA #2 and state an observation.

2. Study the amino acids in Protein #1 and Protein #2 and state an observation.

3. Explain the cause of the difference in the traits of normal and sickle blood cells.

4. Define:

Gene Mutation:

Mutagenic Agent:

Chromosome Mutations

Directions: Below is a sequence of genes represented by letters on a chromosome. Study the changes in the sequences of the genes and select the type of mutation that best describes mutation in each diagram.

Homologous Pair of Chromosomes

Descriptions:

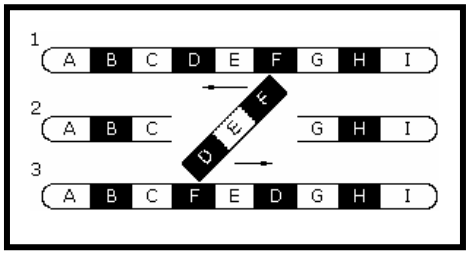
I. Gene Mutations

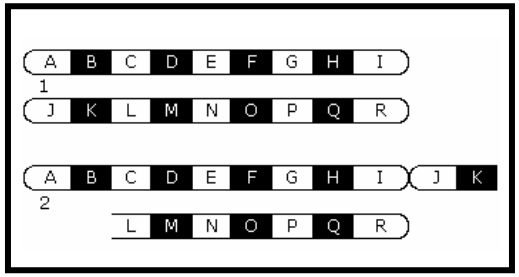
- **Deletion**
  As the name implies, genes of a chromosome are permanently lost as they become unattached to the centromere and are lost forever.
  New chromosome lacks certain genes which may prove fatal depending on how important these genes are.

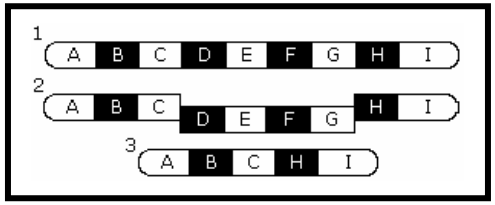
- **Addition**
  In this mutation, the mutants genes are displayed twice on the same chromosome due to duplication of these genes. This can prove to be an advantageous mutation as no genetic information is lost or altered and new genes are gained. New chromosome possesses all its initial genes plus a duplicated one, which is usually harmless

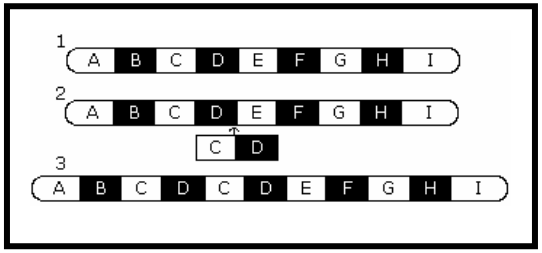
- **Inversion**
  This is where the order of a particular order of genes are reversed. The new sequence may not be viable to produce an organism, depending on which genes are reversed. Advantageous characteristics from this mutation are also possible

- **Inversion**
  This is where information from one of two homologous chromosomes breaks and binds to the other. Usually this sort of mutation is lethal. Translocation of genes has resulted in some genes from one of the chromosomes attaching to the opposing chromosome.





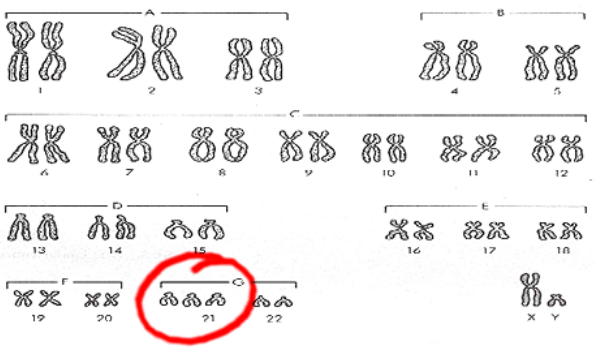




1. _____ **2.** _____ **3.** _____ **4.** _____

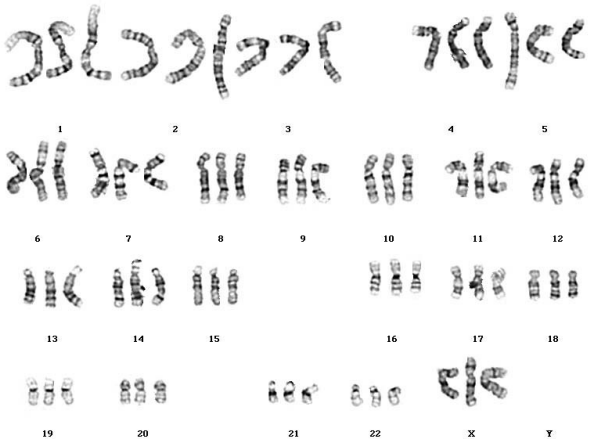
II. Chromosomal Mutations

1. Trisomy Karyotype



Description:

2. Polyploidy Karyotype



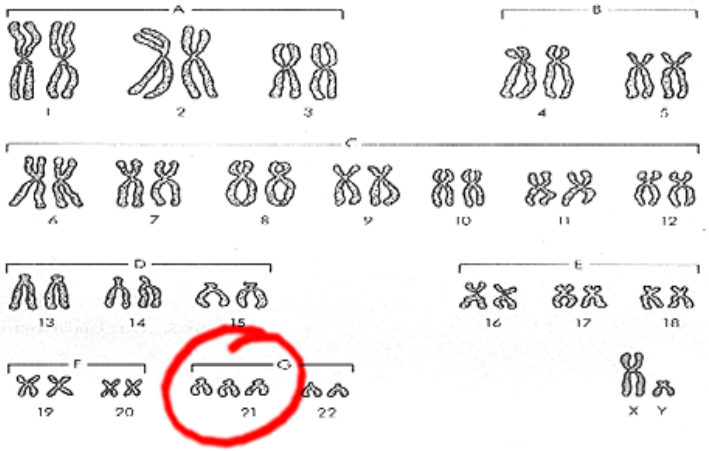
Description:

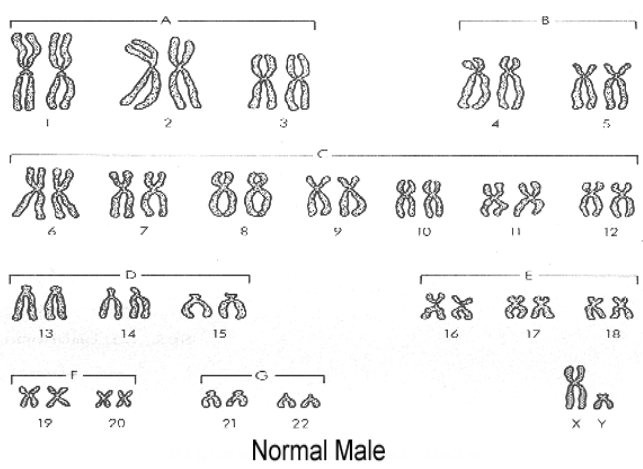
3. Identify the 2 kinds of chromosome mutations.

4. Define: Chromosome Mutation:

Karyotypes

Directions: Below are examples of different karyotypes. In amniocentesis, embryonic cells are removed and pictures are taken of chromosomes which are enlarged, cut out, paired, and glued in place from largest to smallest pair. Identify the following karyotypes: Down Syndrome – extra 21st chromosome (3 chromosomes instead of 2), Cri du chat syndrome – missing part of chromosome #5, Turner Syndrome – only one X sex chromosome in the 23rd pair, and Normal male karyotype.





Normal Male