UNIT 7: BIOTECH, PROTEIN SYNTHESIS, MUTATIONS

DNA/ RNA Review

Genetic Engineering

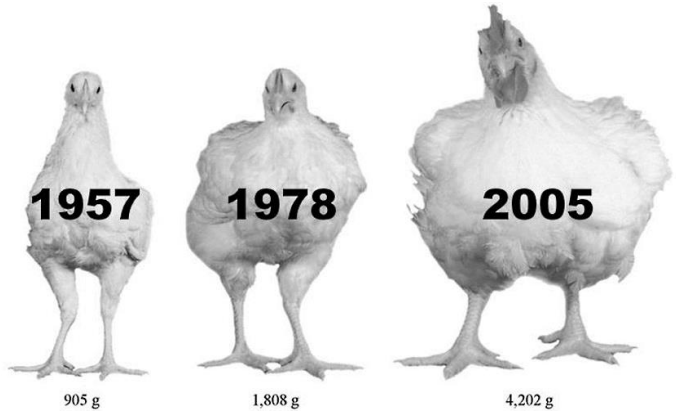
- Genetic engineering is technology that involves manipulating the DNA of one organism in order to insert the DNA of another organism.

- Genetic engineering can be used to increase/decrease the expression of specific genes in selected organisms.

- An organism's genome is the total DNA in the nucleus of each cell.

Applied Genetics: is the manipulation of the hereditary characteristics of an organism to improve or create specific traits in offspring.

- **Selective breeding: (aka artificial selection)** human directed breeding to produce plant and animal with desirable traits. Ex: breeding plants to produce larger fruits/vegetable



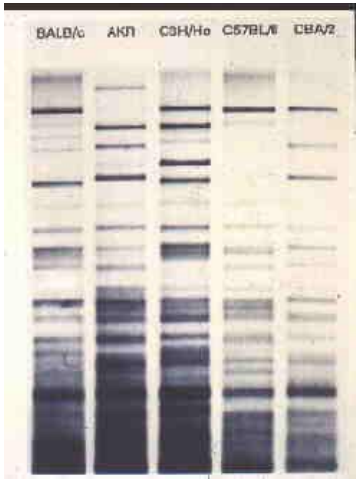
- **Inbreeding:** Two closely related organism are bred to have the desired traits and to eliminate the undesired ones in future generations

Biotechnology

- **Biotechnology** is the use of genetic engineering to find solutions to problems.
- Goal for the **Human Genome Project** was to sequence all the nucleotides in the human body. (3 Billion nucleotides and 20,000-25,000 genes)
- This was completed in 2003.

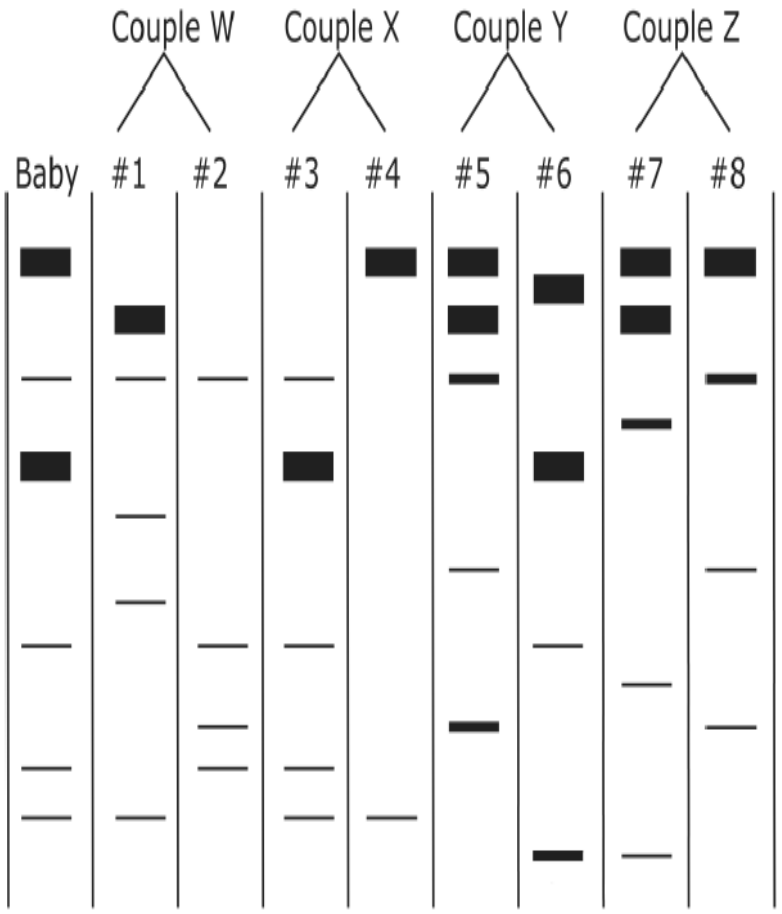
Gel Electrophoresis

- 1. DNA is cut into smaller pieces using restriction enzymes
- 2. An electrical current is applied
- 3. DNA is separated by size. Shorter fragments move farther down the get than longer fragments



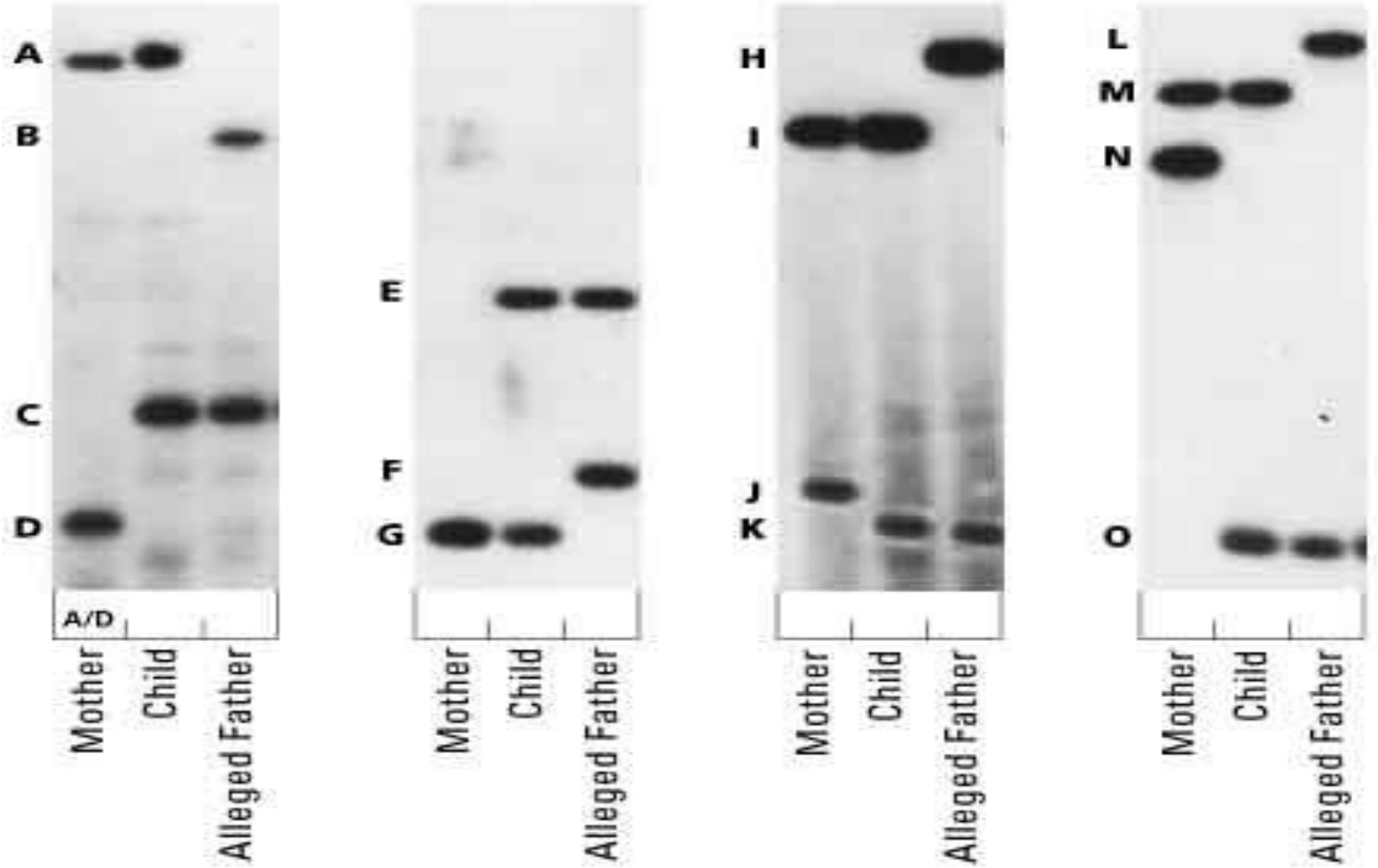
Used in:
DNA fingerprinting

DNA fingerprinting

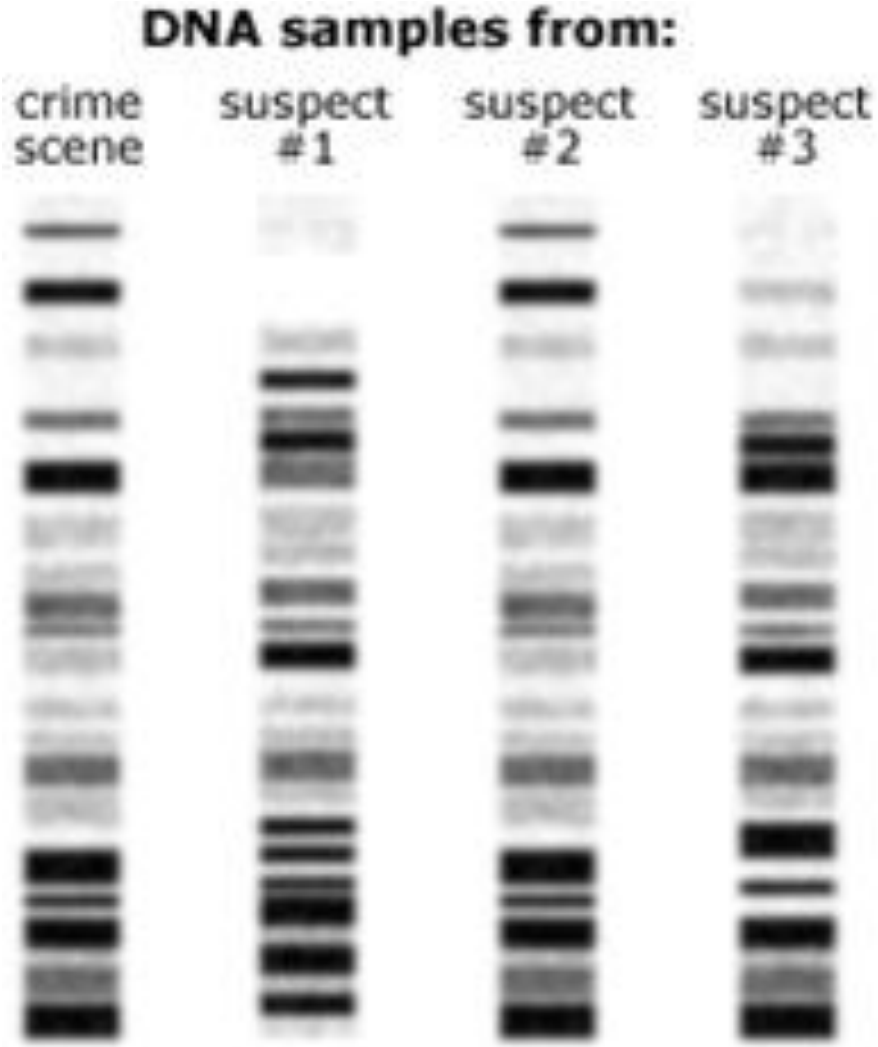


- Best way to determine if two people are genetically related
- Used in genetic counseling, parental testing, crime scenes, classification of new species of organisms.
- **Can you tell…**
  Organism X is most closely related to which sample?

Which one is the correct father?



Gel Electrophoresis (example)



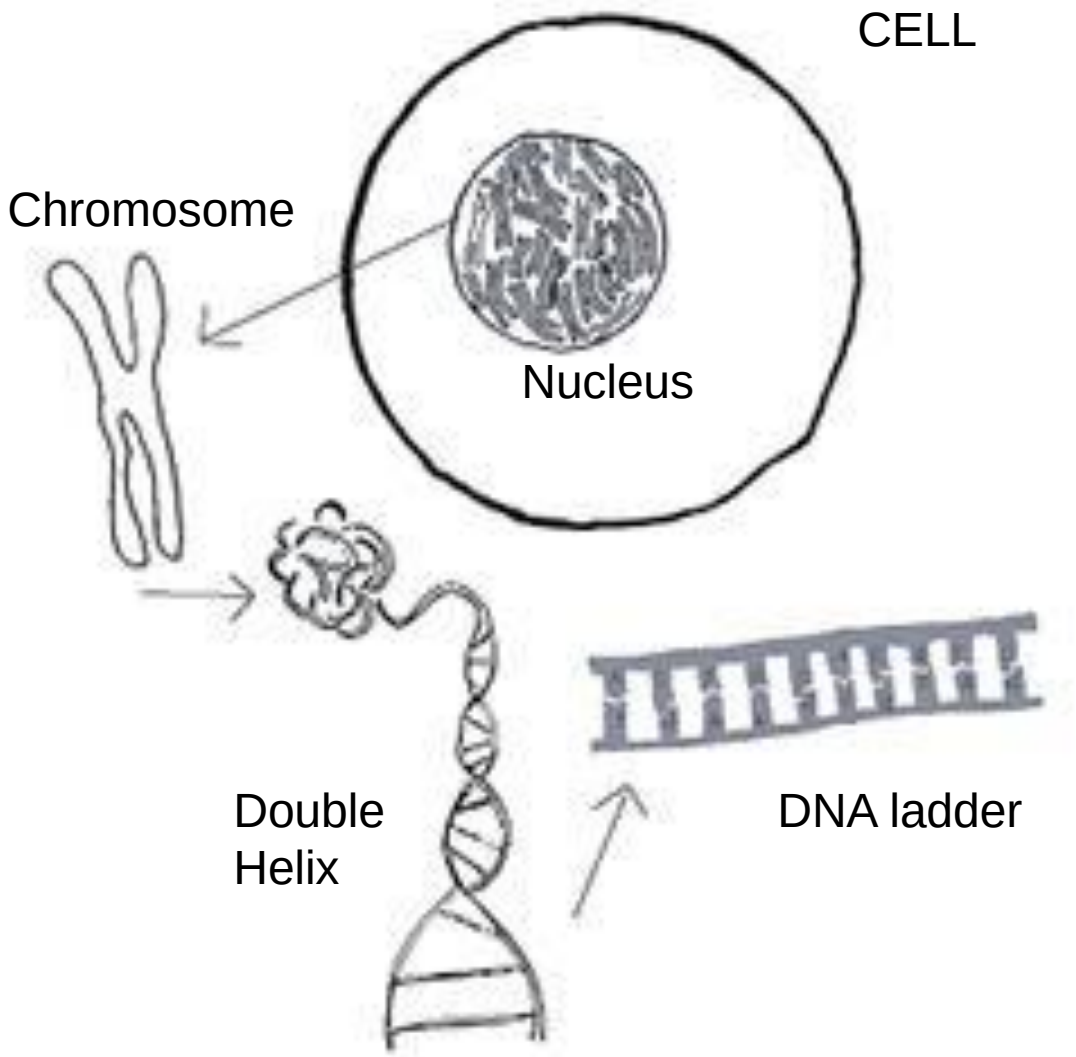
- Look at the example of DNA taken at the crime scene (Column 1).
- Which suspect committed the crime?
  - **Suspect 1**
  - **Suspect 2**
  - **Suspect 3**

DNA – RNA

Objective:

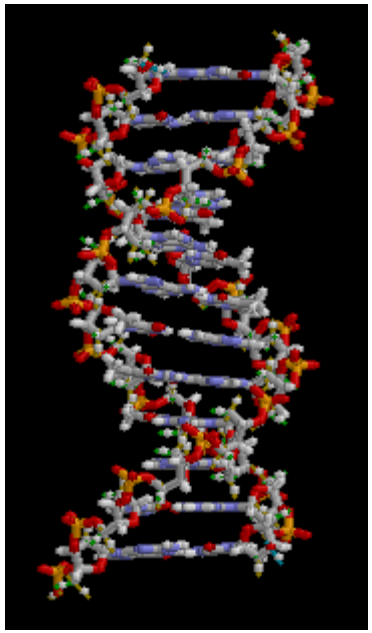
Know the components of DNA compared to RNA

Know what RNA does

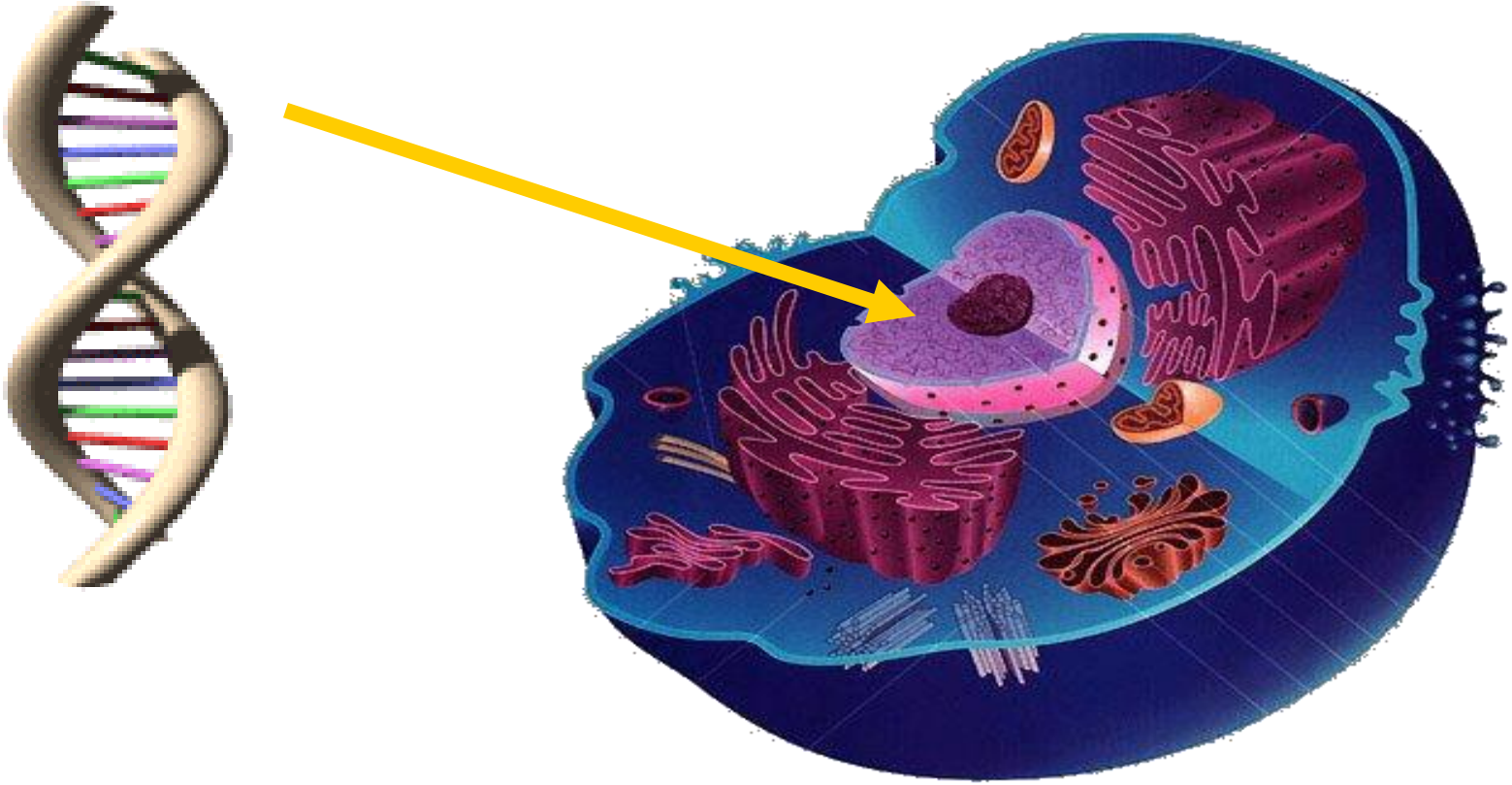


Function of DNA:

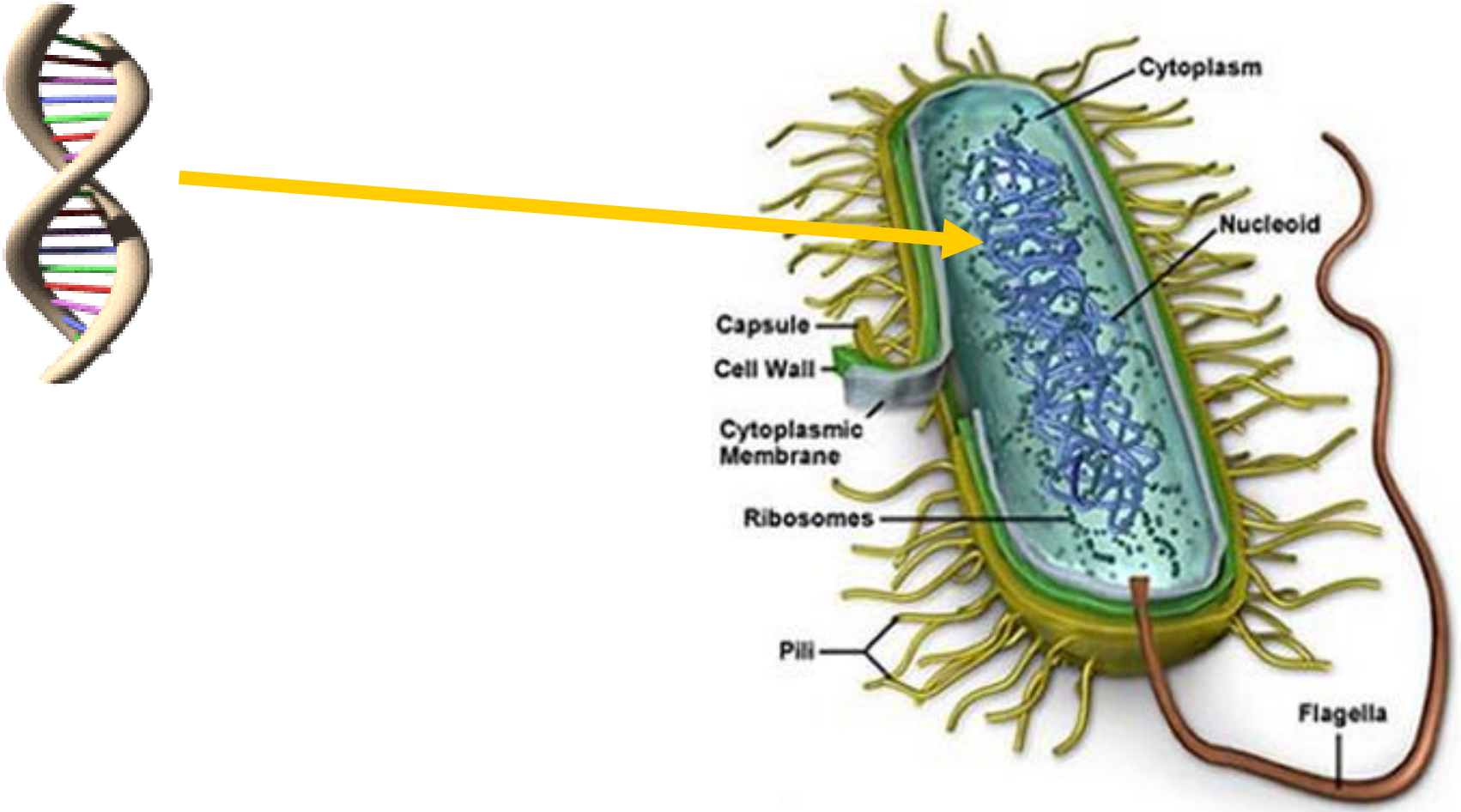
- The master copy of an organism's information code that contains the instructions (blueprint) used to make proteins
- Determines an organism's characteristics (traits).



Located in the **NUCLEUS** of eukaryotic cells.



Floating around in the **CYTOPLASM** of prokaryotic cells.



DNA Structure

- To understand the genetic code found in DNA we need to look at the **sequence of bases**.
- The **sequence of bases** is what determines the traits of an organism, making each species unique.

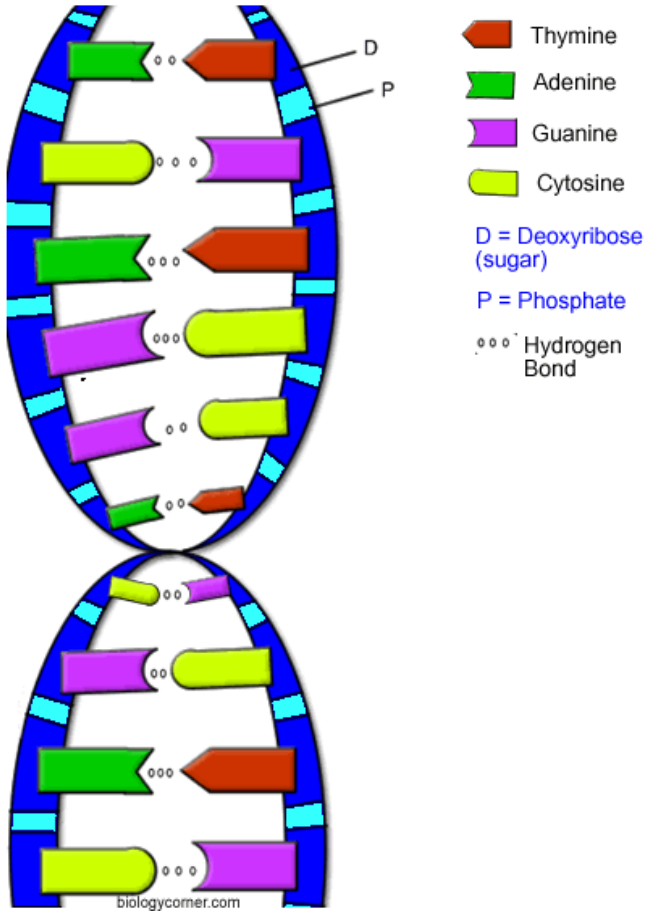
Species	DNA Sequence
DOG	AAC TGA CCT
WOLF	ACC TAG CAT
FOX	AAC TGT CAT
COYOTE	ACC TGA CCT

DNA Review

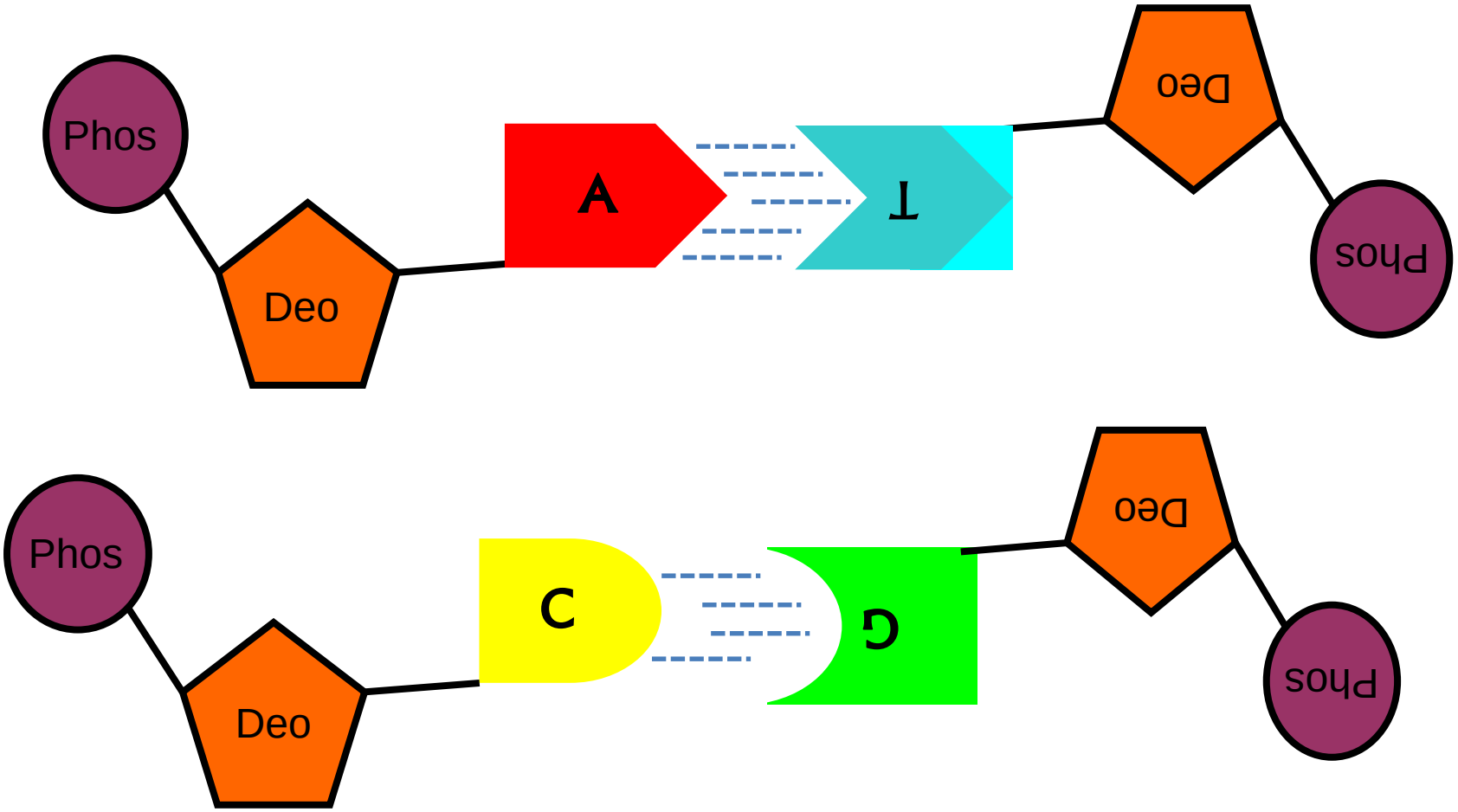
- Shape: **Double Helix**
  - Twisted Ladder
  - **2** complimentary strands

- Made of monomers (units) called **Nucleotides**

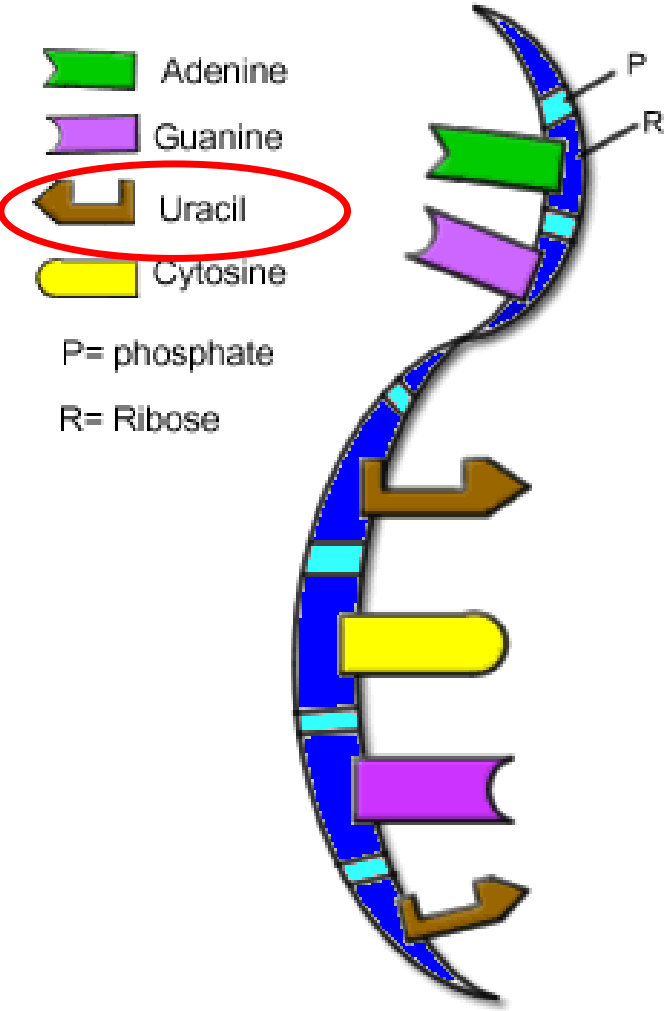
- Nucleotide made of 3 parts:
  A. Phosphate Group
  B. Deoxyribose Sugar
  C. Nitrogenous Bases
    - **Adenine** bonds with **Thymine**
    - **Guanine** bonds with **Cytosine**
    - **Base Pair Rule**: The amount of A's will **equal** the amount of T's, the amount of G's will **equal** the amount of C's
    - Nucleotides are held together by weak **hydrogen bonds**



Nucleotides are held together by weak hydrogen bonds

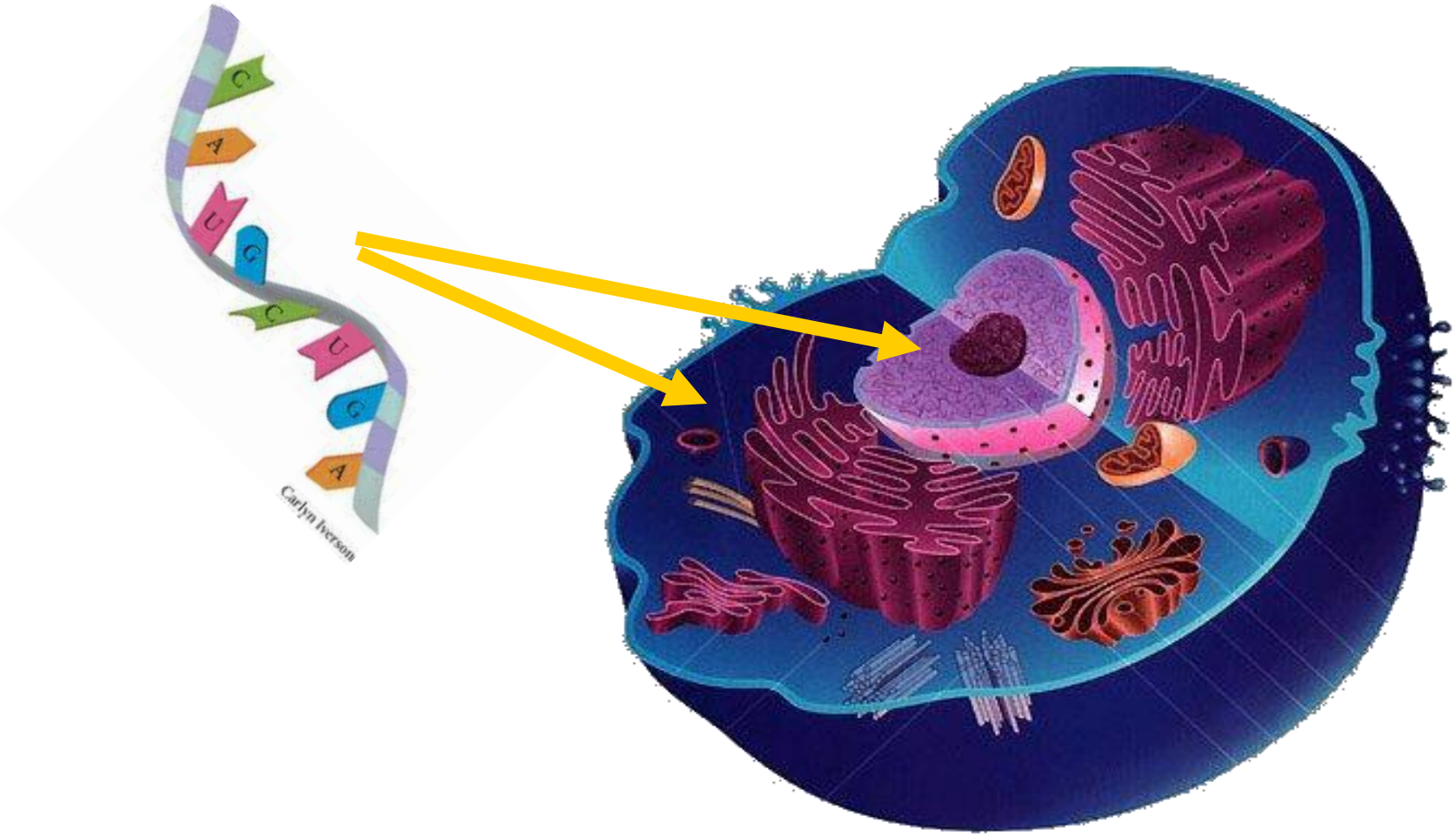


RNA components



- Shape: Helix
  - **Single** strand
  - Half a twisted ladder
- Made of Nucleotides
- Nucleotides made of 3 parts:
  A. Phosphate Group
  B. Ribose Sugar
  C. Nitrogenous Bases
     - **Adenine** bonds with **Uracil**
     - **Guanine** bonds with **Cytosine**

Found in the **nucleus** AND **cytoplasm** of eukaryotic cells.

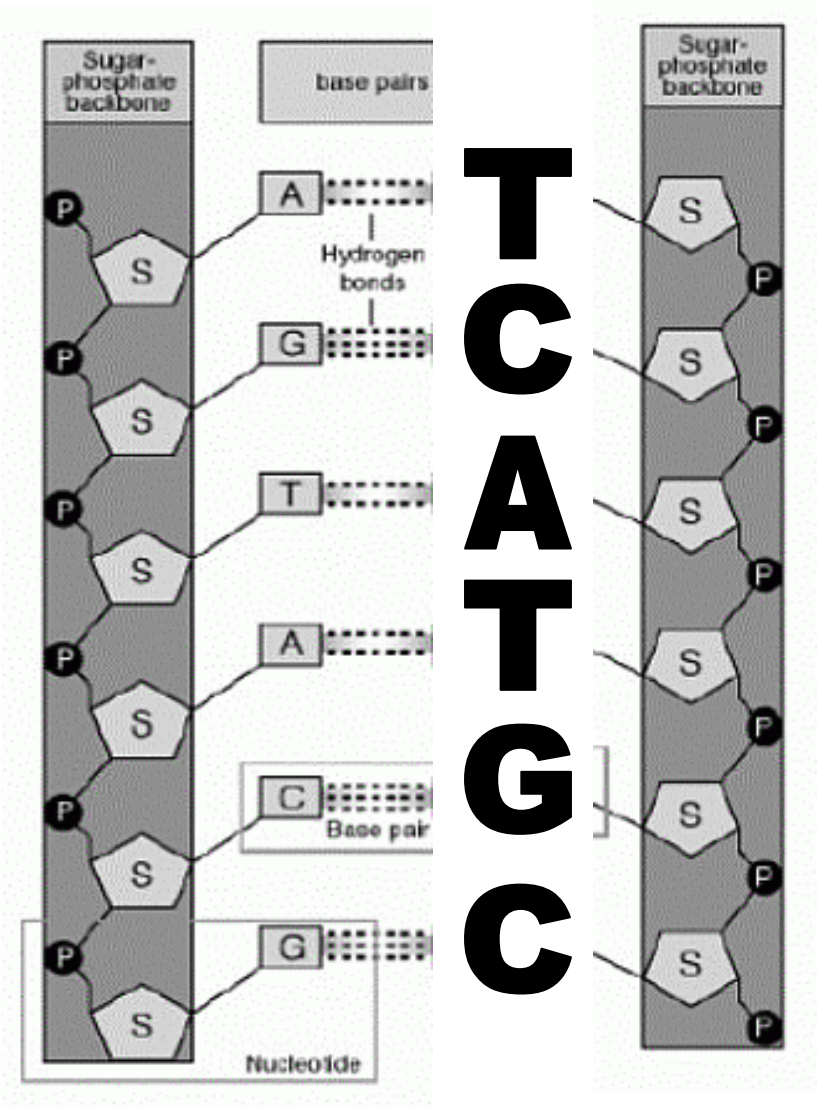


DNA/ RNA Review

	Polymers	
	DNA	**RNA**
# of Strands	2	1
Shape	Double helix	Single stranded
Monomers	Nucleotide	Nucleotide
Sugar	Deoxyribose	Ribose
Bases	A, T, C, G	A, U, C, G
Location	Nucleus only	Nucleus & cytoplasm

DNA to DNA base pairing review

DNA

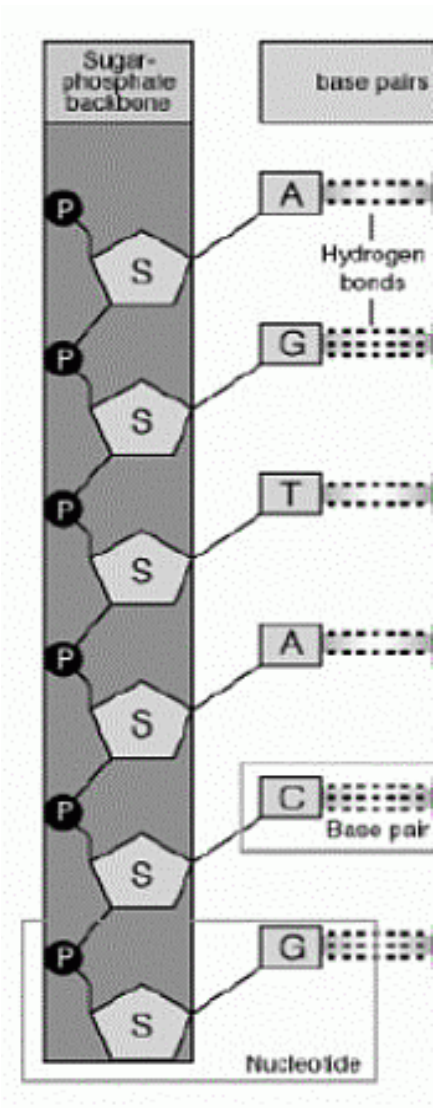


T
C
A
T
G
C

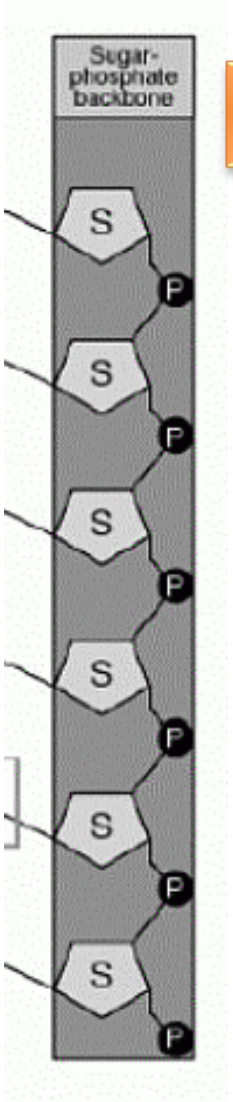
DNA

DNA to RNA base pairing

DNA



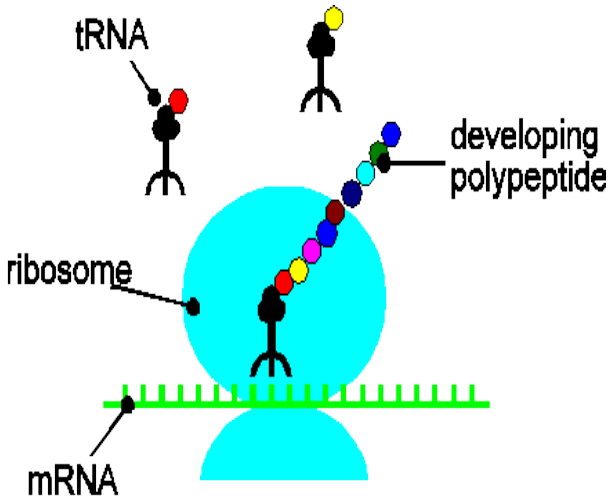
U
C
A
U
G
C



RNA

There are 3 types of RNA

- Messenger RNA (mRNA)- The function of mRNA is to TRANSCRIBE (make of copy of) DNA and carry the copy to the ribosomes to make proteins.
  - **DNA cannot leave the nucleus for any reason!**

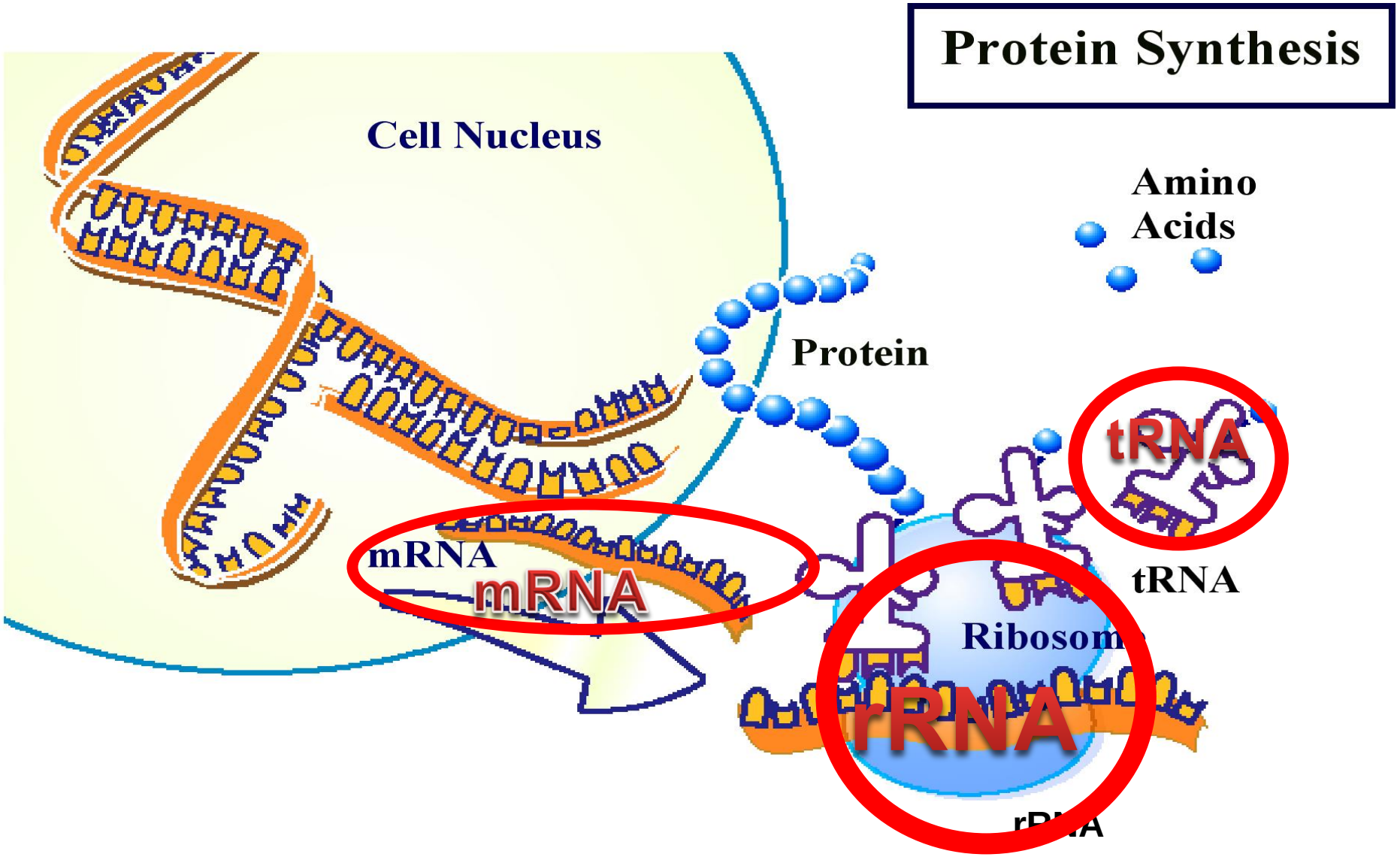


- Transfer RNA (tRNA)- The function of tRNA is to READ and TRANSLATE the mRNA and bring the correct amino acid (protein) to the ribosome.

- Ribosomal RNA (rRNA)- The function of rRNA is to connect the amino acids to build the finished protein.

All Together: What Does RNA do?

BUILD proteins! Circle the RNAs



Why are proteins important?

PROTEINS WILL **BUILD** TRAITS

DNA → RNA → PROTEINS → TRAITS (**phenotype**)

This is called Gene Expression

- Function of Proteins
  - Enzymes
  - **Build** cells, tissues, etc…
  - **Repair** and maintenance of body
  - Hormones
  - **Transport** of materials (in/out of cell
  - Emergency **energy** source

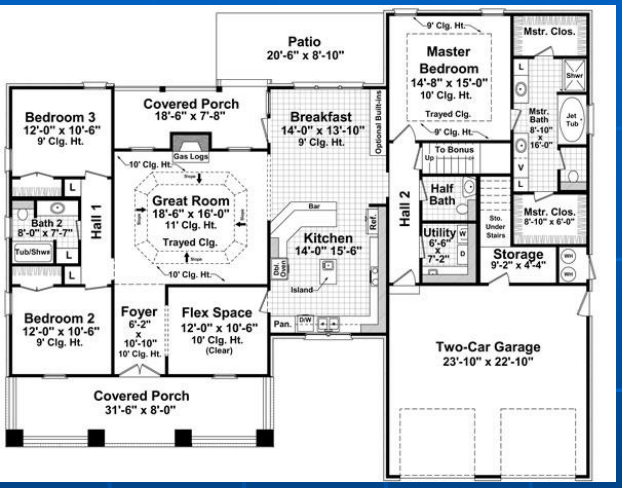
VIDEO:
Compare/Contrast
DNA vs. RNA

Amoeba Sisters

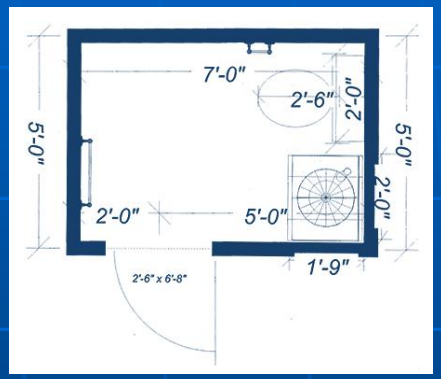
Complete DNA/RNA Worksheet

How do I get from the instructions to building a HOUSE?

ALL of the master Instructions



Bathroom instructions



Bathroom materials

Home

Bathroom

How do I get from the instructions to building YOU?

DNA: The master Instructions

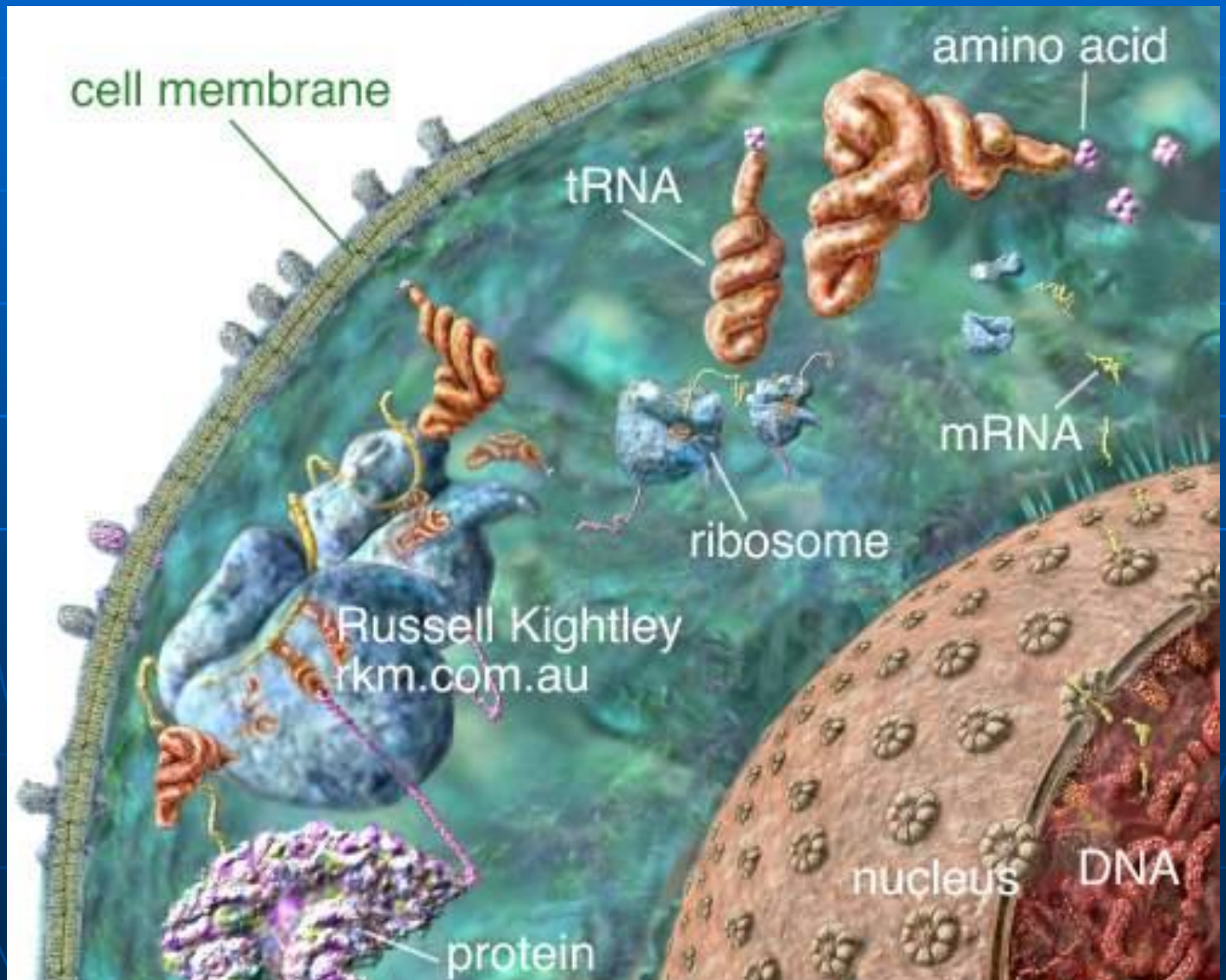
Genes: parts of the instructions

Proteins: building blocks!!!

Proteins

Cells: basic unit of life

Protein Synthesis



Protein Synthesis

Also called Gene Expression

- Protein Synthesis the process of **cells making PROTEINS to show genetic TRAITS using DNA instructions.**
  - Part 1. Transcription (in the nucleus)
  - Part 2. Translation (in the cytoplasm)

Intro VIDEO (Play just the first 1.5 minutes)

Part 1 Gene Expression

Transcription

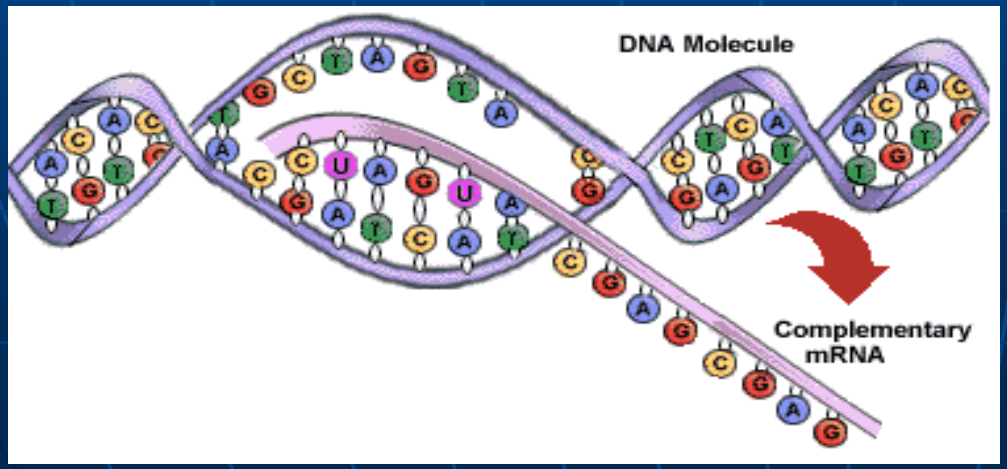
Transcription

- Transcription – to copy DNA instructions into messenger RNA (mRNA)
- Transcription occurs in the nucleus.
- Steps:

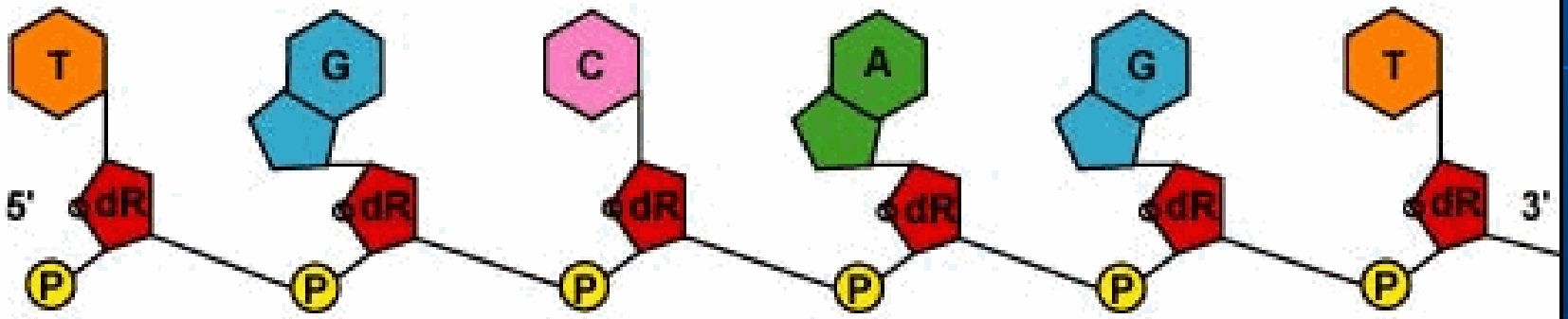
  1) DNA unzips

  2) RNA nucleotides bond A=U C=G

  3) messenger RNA (mRNA) is created



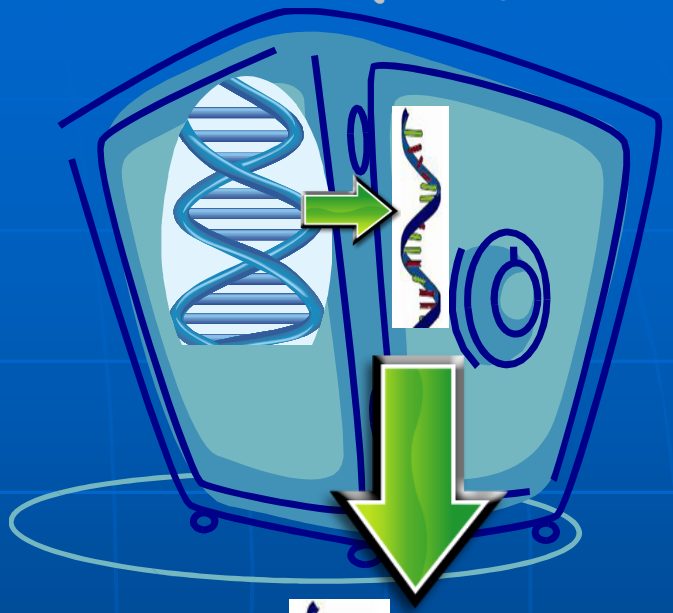
Transcription



Portion of unwound DNA with unpaired deoxyribonucleotides.

Structure and Function of mRNA

- mRNA is a copy of a DNA strand
- The mRNA is made in the nucleus
- mRNA takes genetic information from the nucleus into the cytoplasm to the RIBOSOME for protein synthesis



because DNA CANNOT leave the nucleus (or DNA will get destroyed)

TRANSCRIBE the DNA into mRNA

1) GCATAC CGUAUG

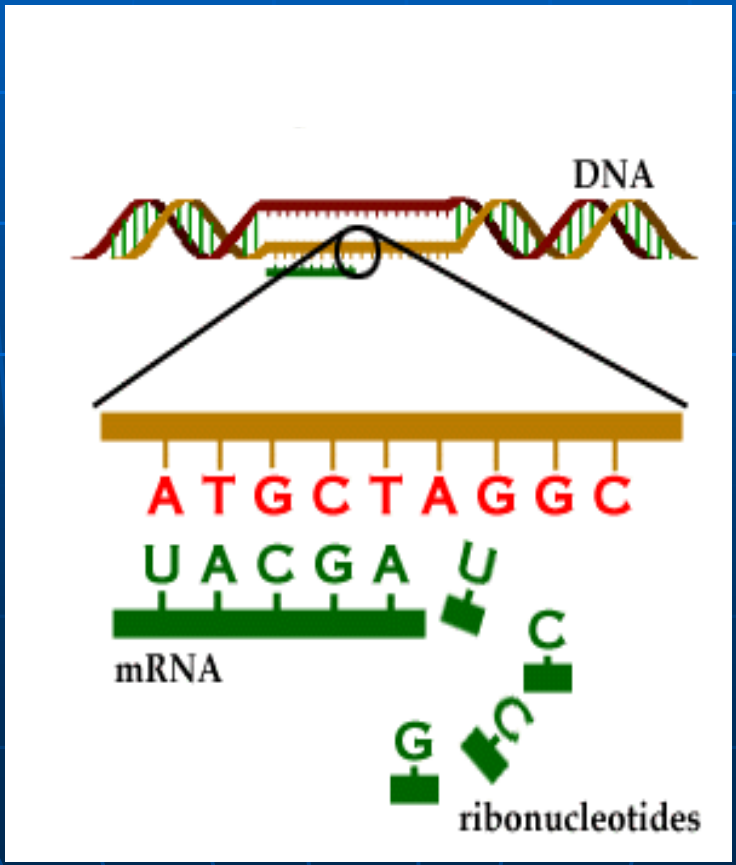
2) ATACGC UAUGCG

3) CGAATT GCUUAA

Video
Animation

Review

- **What process produces mRNA?**
- **Why do you need to make mRNA?**



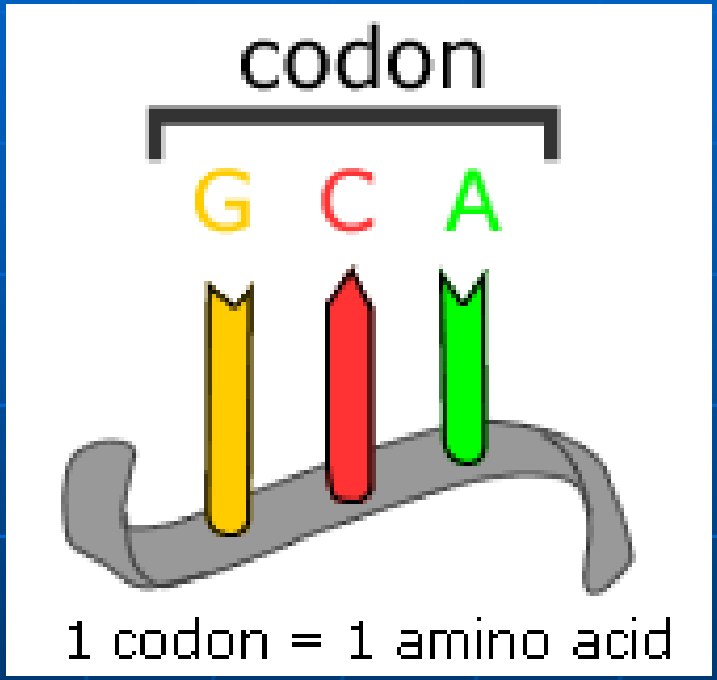
mRNA holds the code for Protein Synthesis

- The nitrogenous bases on the mRNA create a code for protein synthesis

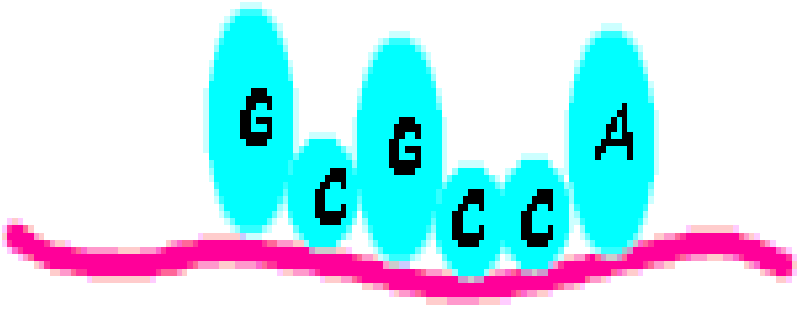
- 3 nitrogenous bases on mRNA are known as a codon

- 3 nitrogenous bases = 1 codon = 1 amino acid

- Proteins are made of amino acids



The RNA Code



- RNA Codon

How many codons are there? 2

How many amino acids will you code for? 2

Part 2 Gene Expression

Translation

Translation

- **Translation-** making a sequence of amino acids from mRNA to build the protein

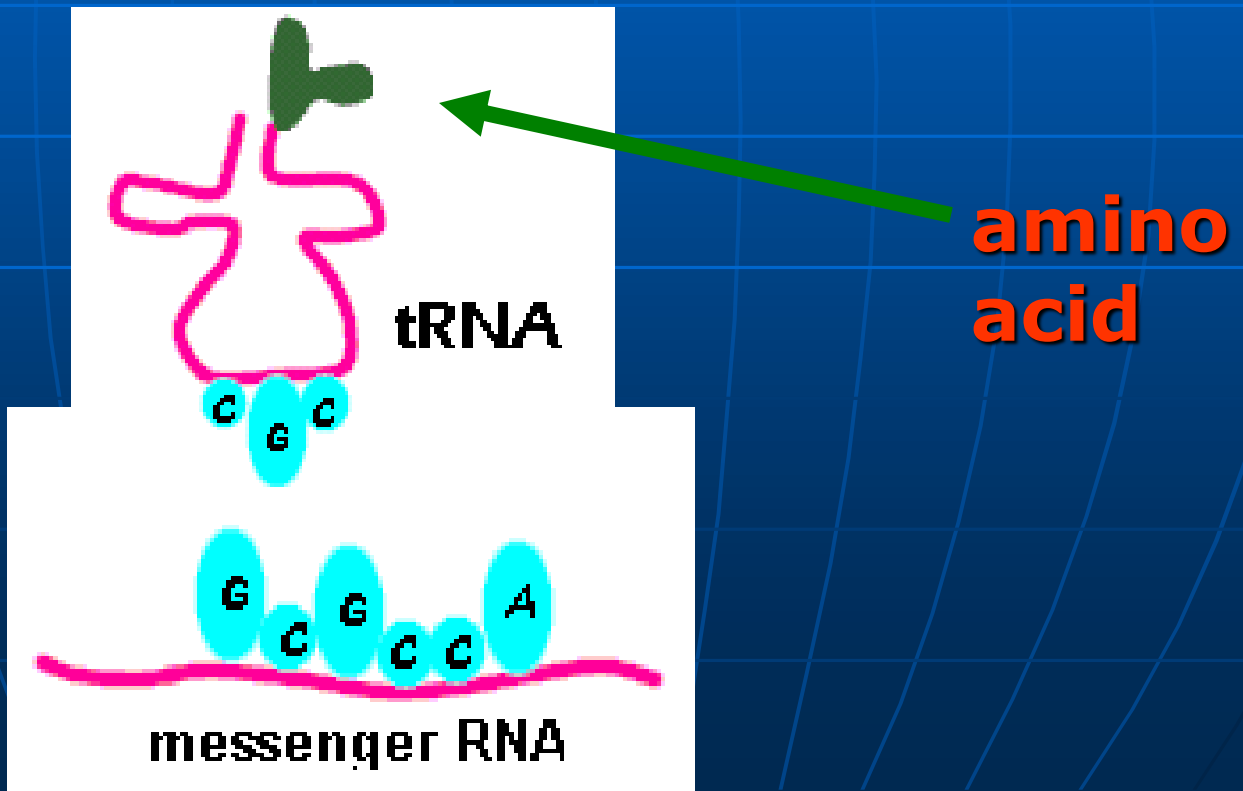
- Translation occurs in the cytoplasm

- Steps:
  1) mRNA attaches to a ribosome
  2) ribosome reads the mRNA
  3) tRNA carries the correct amino acids
  4) Protein is synthesized (made).

Structure and Function of tRNA

Transfer RNA (tRNA):

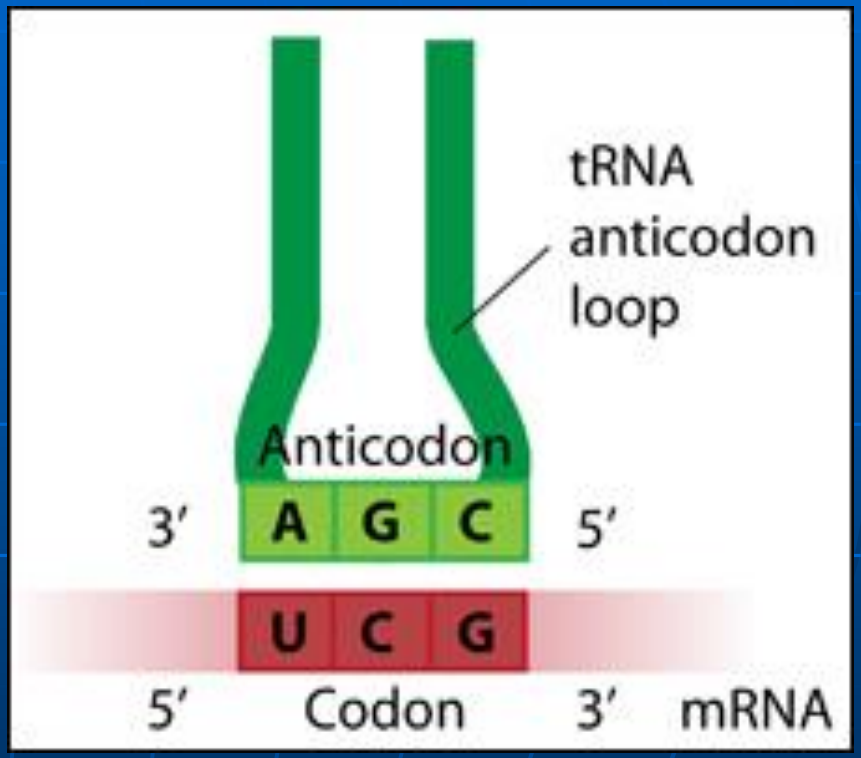
reads the mRNA & carries a specific amino acids to ribosome in order to make proteins



Matching of mRNA to tRNA

- 3 nitrogenous bases of mRNA must match 3 nitrogenous bases of tRNA

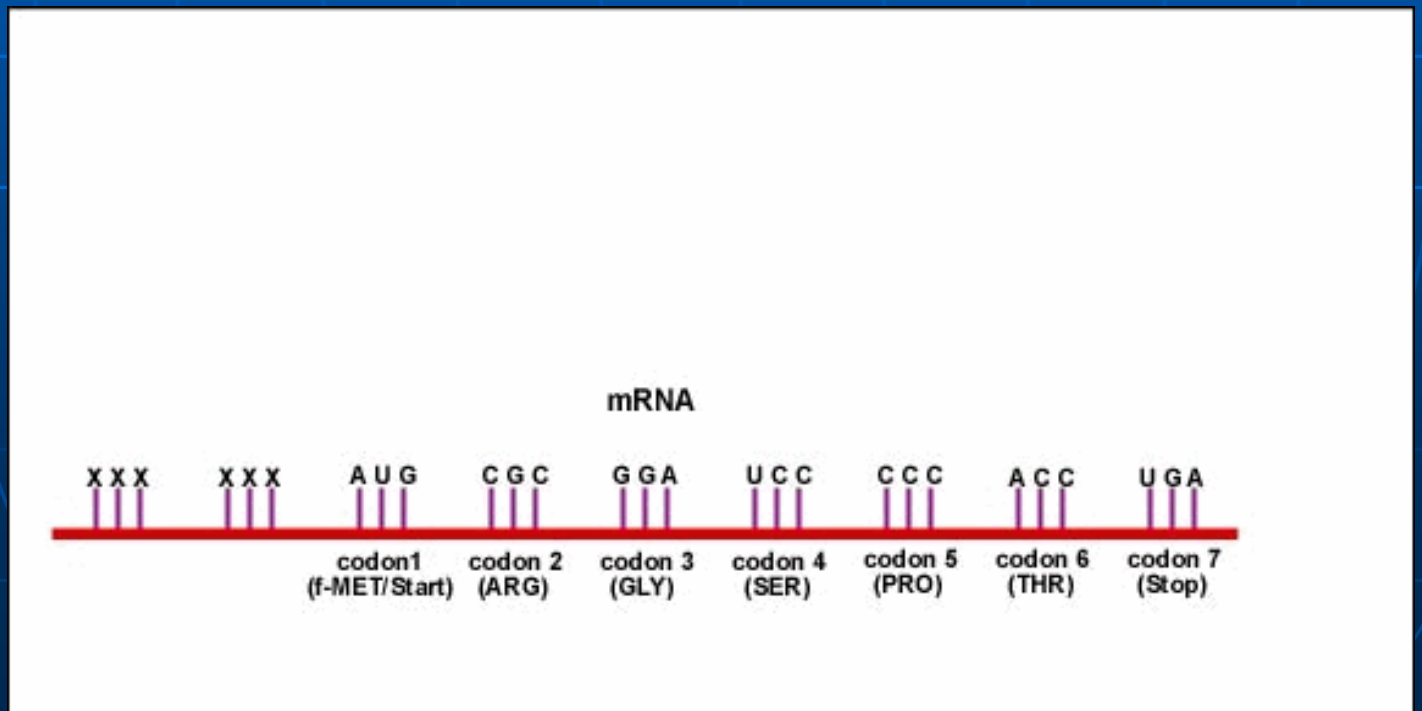
- The mRNA codon is matched with 3 nitrogenous bases of the tRNA called the ANTICODON.



Translation

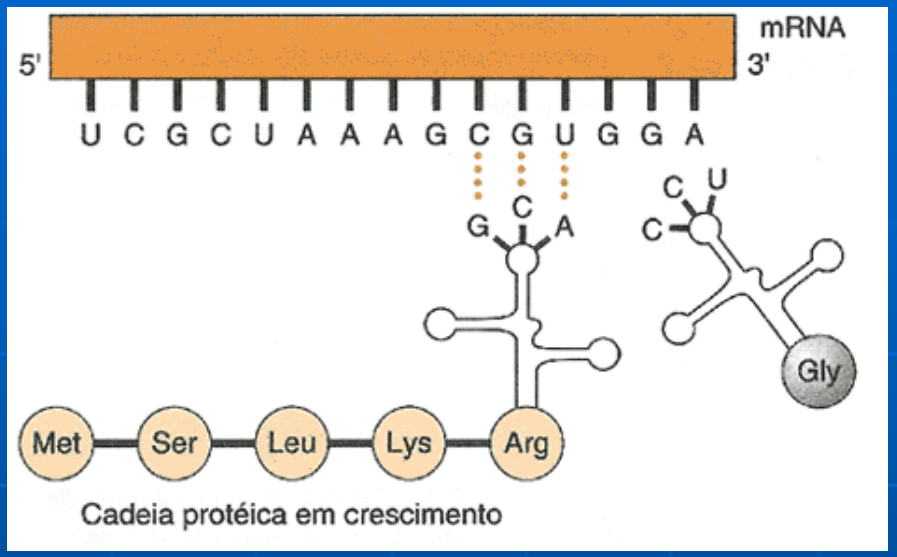
- As each anticodon matches a codon on mRNA it drops off an amino acid that forms a bond to another amino acid

- Multiple amino acids create a protein

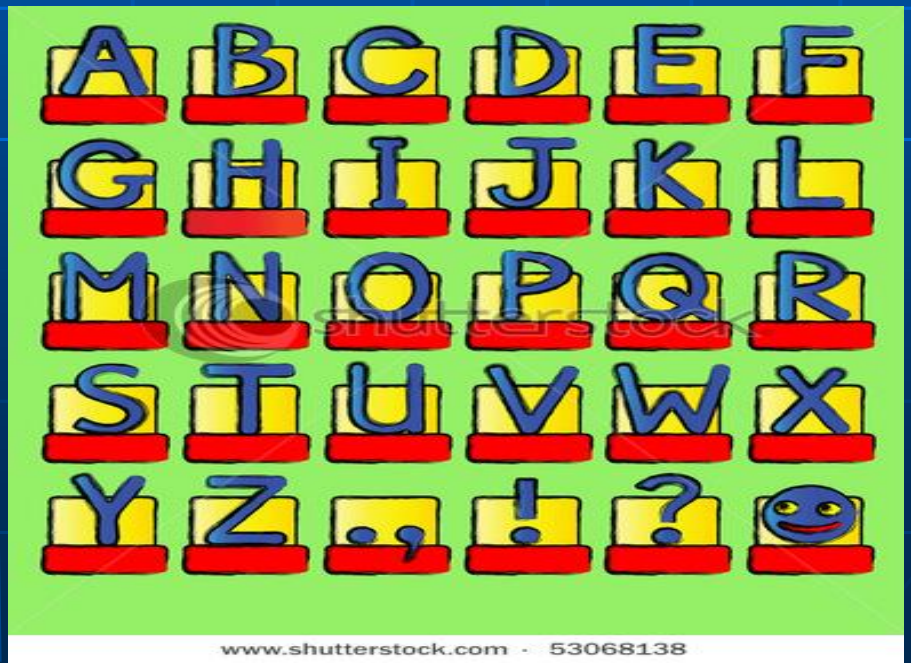


Codons and Anticodons

- On the mRNA strand there is a start and stop codon (3 nitrogenous bases)



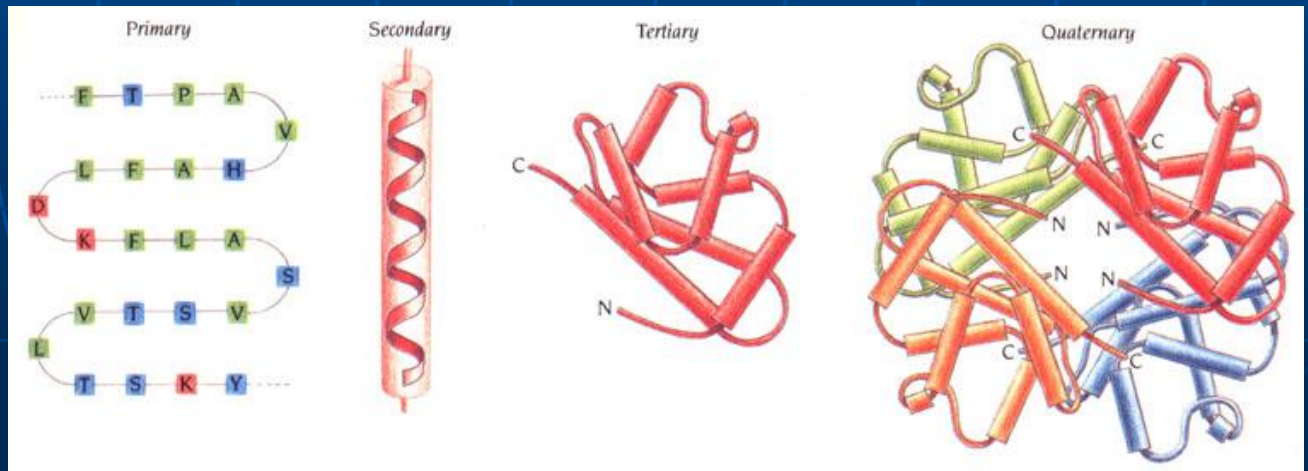
- The protein must start and stop with specific amino acids just like a sentence has a capitol letter and a punctuation mark.



Amino Acids

- All of the proteins in your body are made up of combinations of only 20 different amino acids linked together in different ways.

- (see codon chart)



*There are multiple codons for the same amino acids to help prevent mutations that may occur in DNA.

FIND: AUG, GAA, CGA, UAG

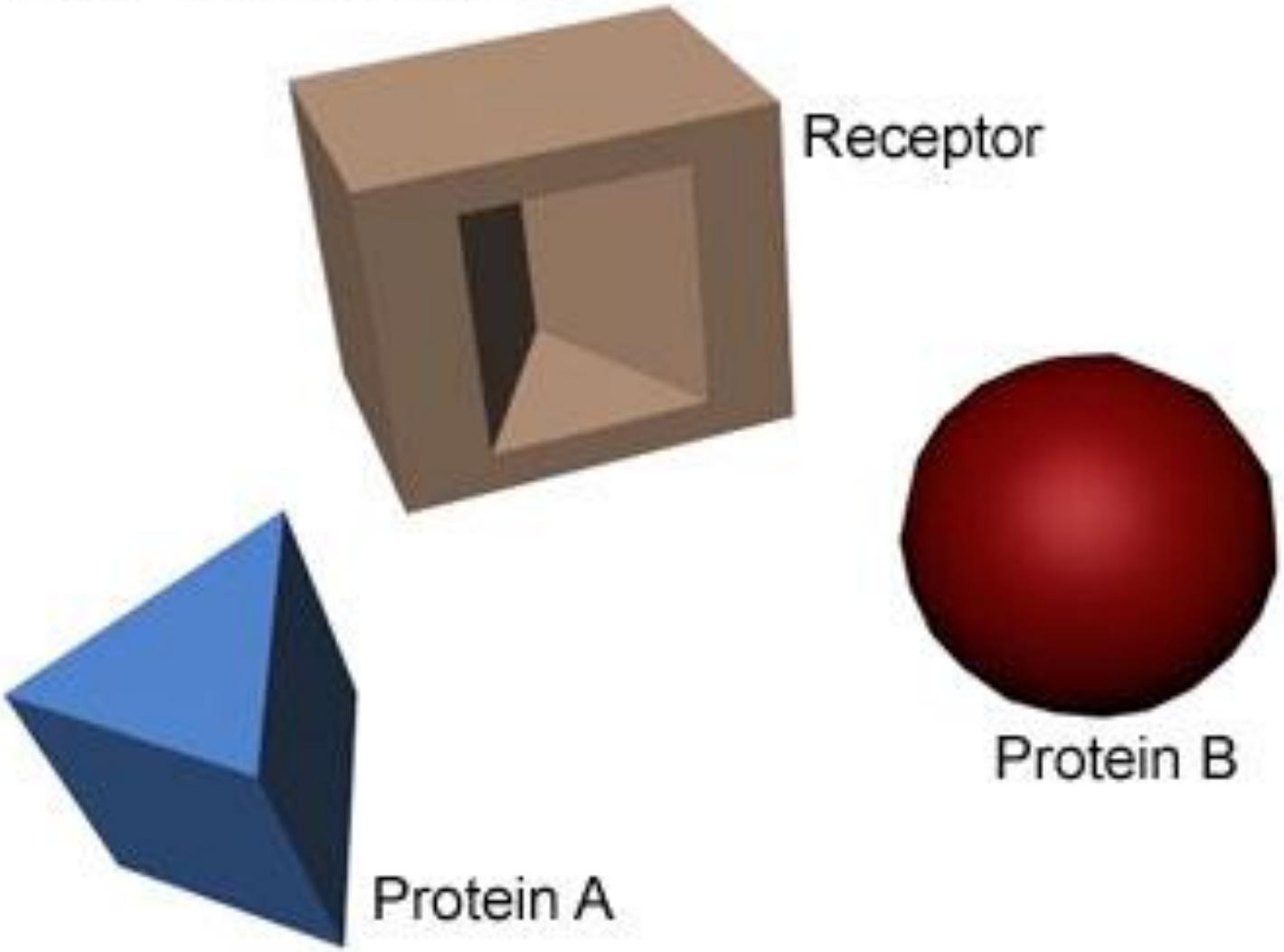
First Letter	Second Letter				Third Letter
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	stop	stop	A
	leucine	serine	stop	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	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

Video: Protein Synthesis

Amoeba Sisters

- Gene expression = protein produced
- DNA → RNA → Amino Acid →Protein→ Protein Shape→ Protein Function
- The shape of the protein and the order of the amino acids determines the function of the protein

Figure A-2: Protein Shape



Shape determines how proteins interact with their environment: due to its shape, protein A will bind with the rectangular receptor, but protein B cannot.

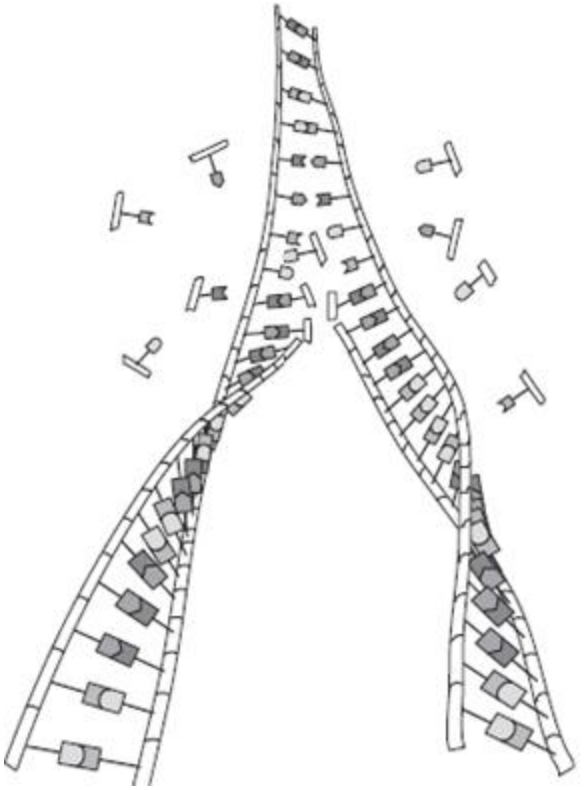
Influences on Gene Expression

- **Genes can be turned on OR off. This is called gene regulation.**
- **Gene regulation allows cells to react quickly to changes in their environments.**
- **Environmental Influences – factors that influence the expression of a gene**
  - **Temperature, nutrition, light, pathogens**
  - **Ex. Temperature effects the expression of the coat color gene in Arctic Foxes**

Mutations

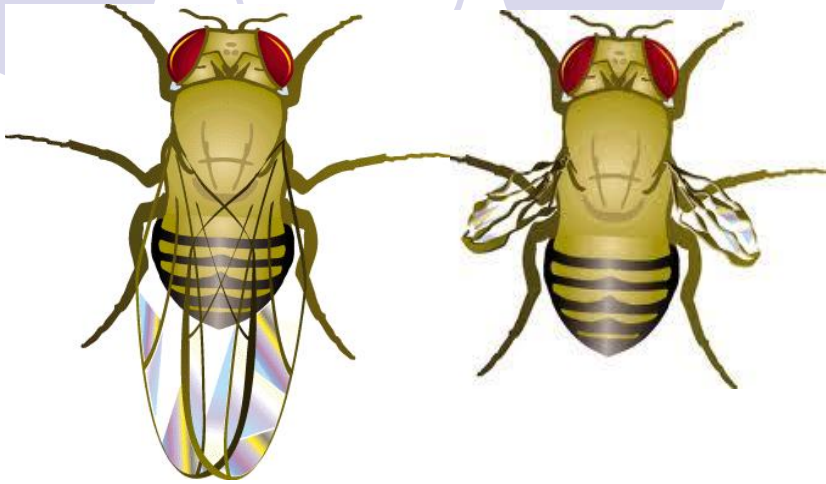
Mutations

- any **CHANGE** in the **DNA** sequence
- It's a **MISTAKE** that's made during **replication** or **transcription**



Mutations: good or bad?

- **harmful:** <u>diseases</u> or deformities
- **helpful:** organism is better able to <u>survive</u> (camouflage, adaptation)
- **neutral:** organism is <u>unaffected</u>

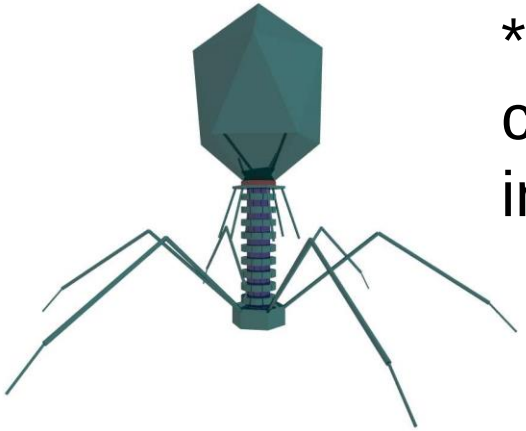


NORMAL **MUTATION**

Causes of mutations

- **Mutagens**: anything that causes a change in DNA
- examples: Viruses, X rays, UV light, nuclear radiation, cigarette smoke
- Mutations are random events
  - Chances of mutations occurring naturally 1/1,000,000
  - Mutations due to mutagens usually 1/100,000

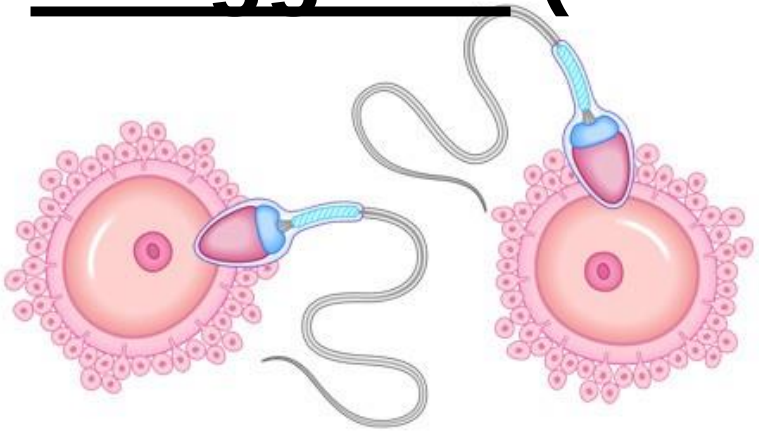
What are the mutagens?



*remember that viruses can cause changes in the HOST DNA when they insert their viral DNA for replication!

Can you give a mutation (mistake) to your kids?

- YES, if a mutation occurs in a **sperm or egg cell (heredity)**



- NO, if a mutation occurs in a **body cell** (example skin cell)

Point Mutations **AKA SUBSTITUTION**

- Bases are mismatched!

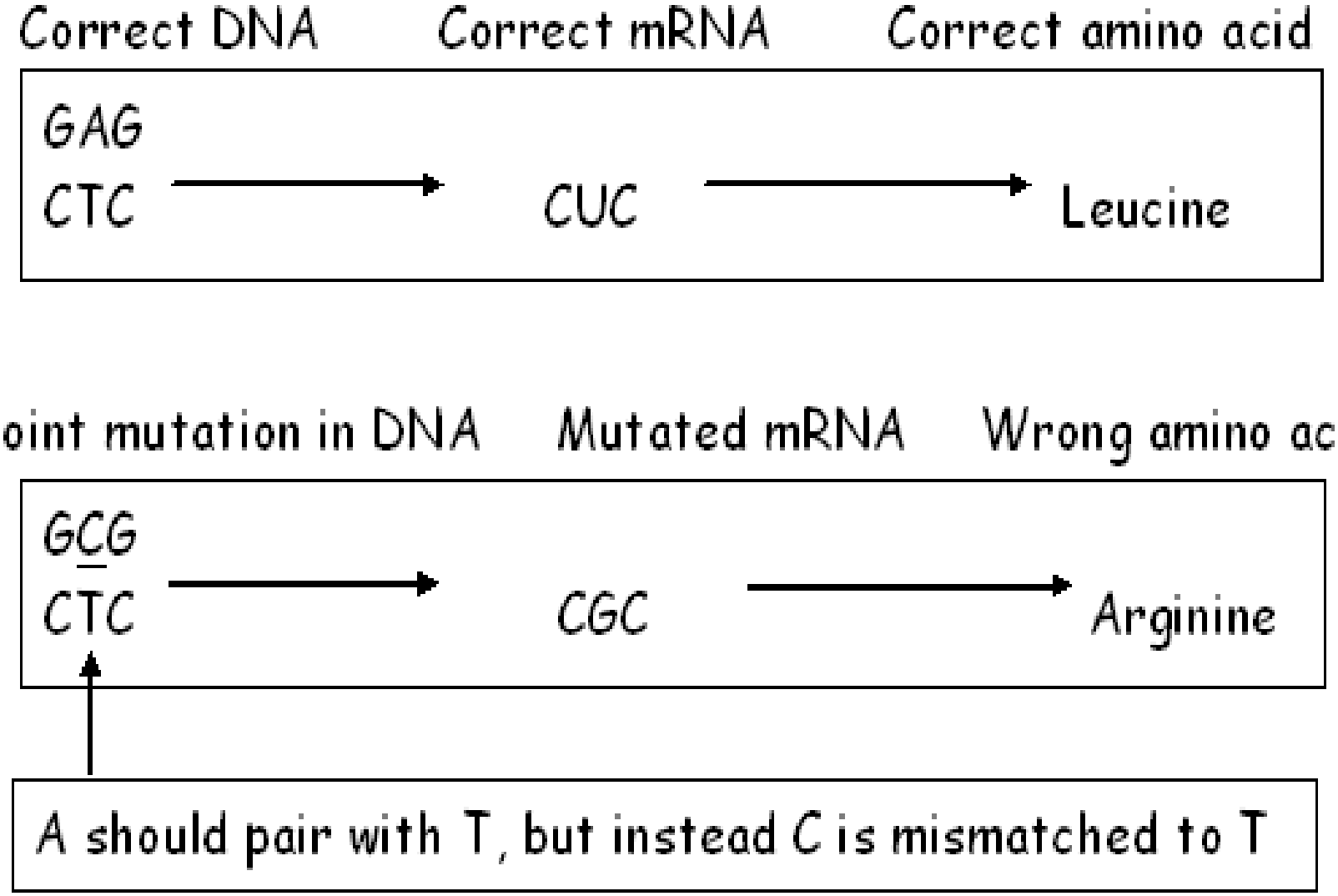
- **Harmful**: when a mistake in DNA is carried into mRNA and results in ONE wrong amino acid

- For example: read the following sentence

Original: *The fat cat ate the rat.*

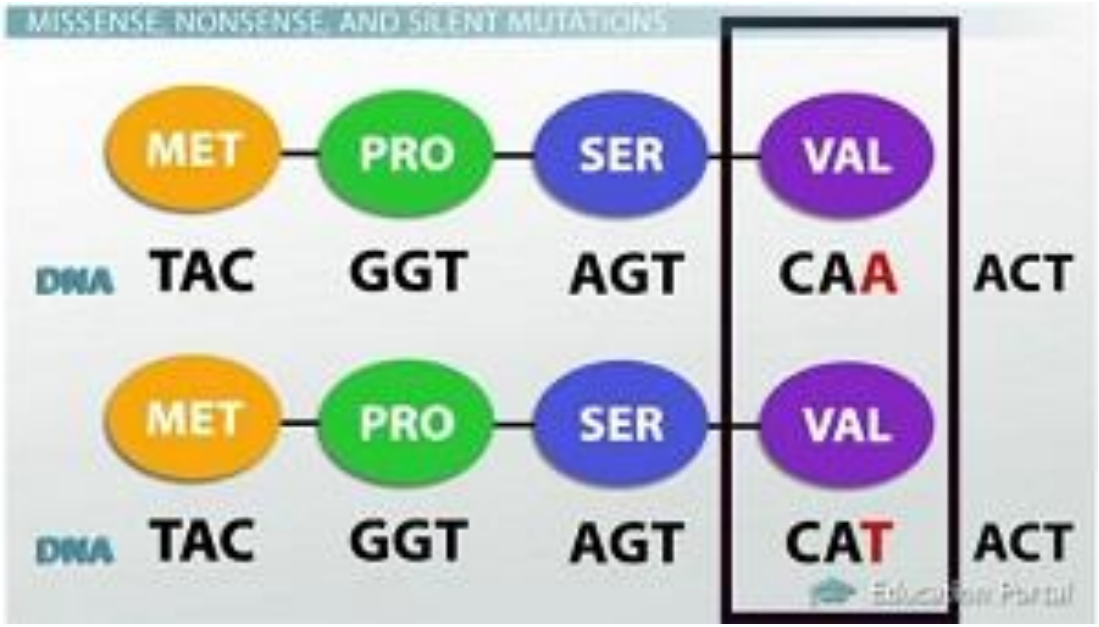
Point Mutation: *The fat hat ate the rat.*

Point Mutations



Point mutations can be NOT harmful when a mistake in DNA is carried into mRNA but still results in the CORRECT amino acid.

The DNA mutated but if protein is NOT changed- then it will function and everything is okay.



CA**A** is changed to CA**T** but it still results in the same amino acid **VALINE.**

This means that even though you have a mutation- the protein will stay the same, having NO affect on you!

First Position	Second Position: U code	U Amino Acid	C code	C Amino Acid	A code	A Amino Acid	G code	G Amino Acid	Third Position
U	UUU	phe	UCU	ser	UAU	tyr	UGU	cys	U
	UUC		UCC		UAC		UGC		C
	UUA	leu	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	trp	G
C	CUU	leu	CCU	pro	CAU	his	CGU	arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	ile	ACU	thr	AAU	asn	AGU	ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lys	AGA	arg	A
	AUG	met	ACG		AAG		AGG		G
G	GUU	val	GCU	ala	GAU	asp	GGU	gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glu	GGA		A
	GUG		GCG		GAG		GGG		G

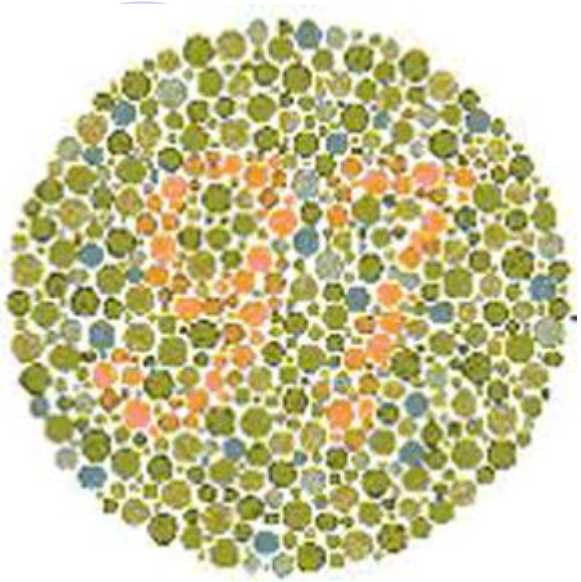
Point Mutation-

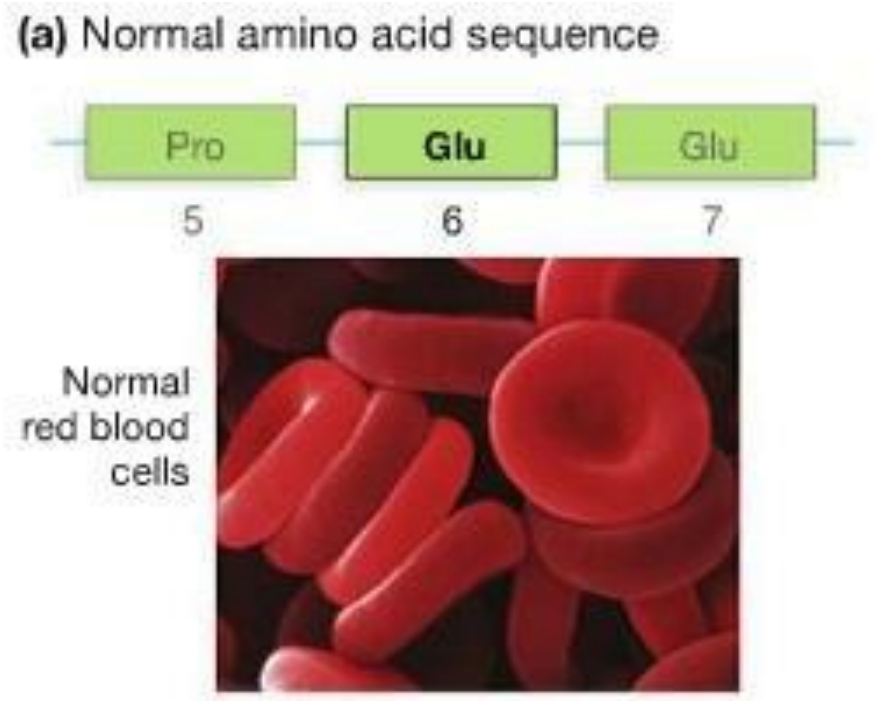
harmful when amino acid is different CAC = histidine CCC= proline

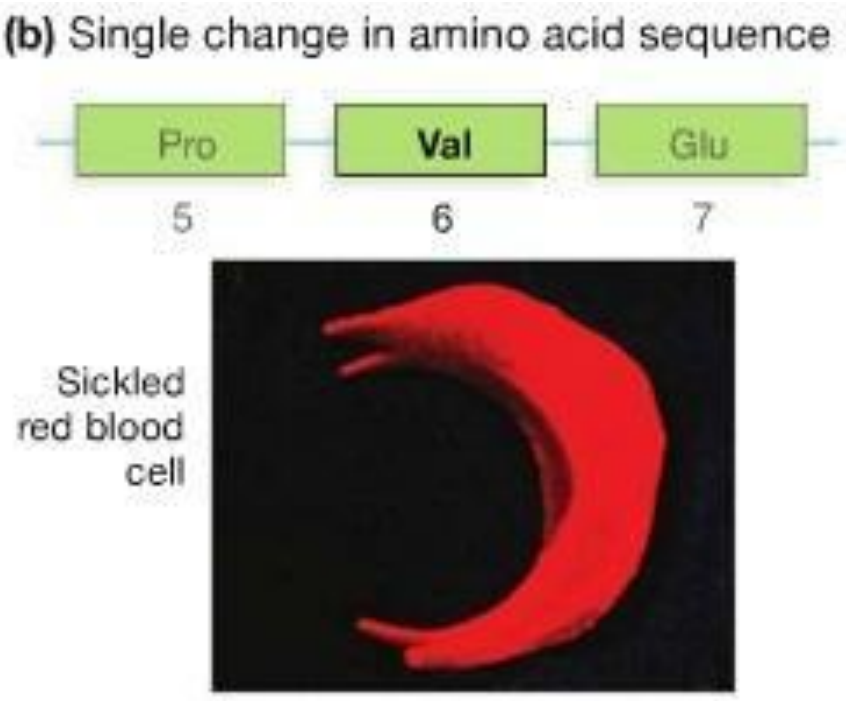
not harmful when amino acid is same CAC= histidine CAU= histidine

Examples of Point Mutation

- Sickle cell anemia
- Color blindness
- albinism







Albinism- complete or partial absence of pigment in the skin, hair and eyes due to absence or defect of tyrosinase, a copper-containing enzyme involved in the production of melanin; results from inheritance of recessive gene alleles; associated with vision defects and increase susceptibility to sunburn/skin cancer

Probability to produce albino?

Aa x aa

	a	a
A	Aa	Aa
a	aa	aa

p = 1/2

Aa x Aa

	A	a
A	AA	Aa
a	Aa	aa

p = 1/4

AA x aa

	a	a
A	Aa	Aa
A	Aa	Aa

p = 0

Think about this!

What kind of mutation is this?

UAC ⟶ UAA

What will happen if this particular mutation occurred at the beginning of a protein?

Frameshift mutations

- Bases are inserted (put in) or deleted (take out)
- Very **harmful** because a mistake in DNA is carried into mRNA and results in **many wrong** amino acids

- For example, read the following sentence

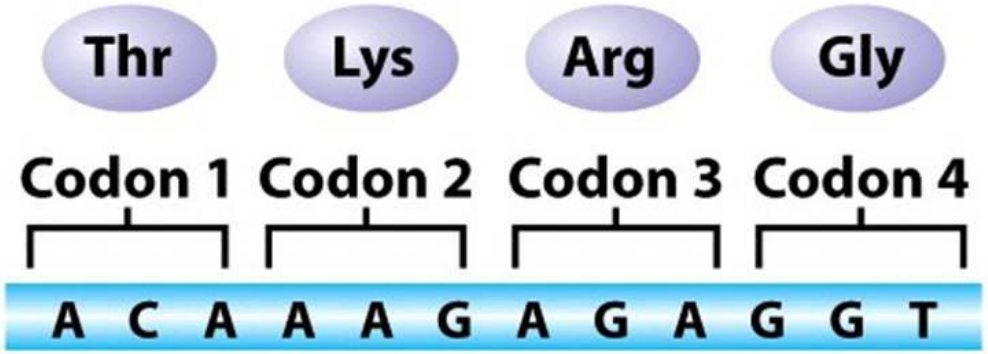
Original: The fat cat ate the wee rat.

Frame Shift: The fat ca**a tet hew eer at**.

The “t” in cat was deleted causing most of the sentence to be wrong!

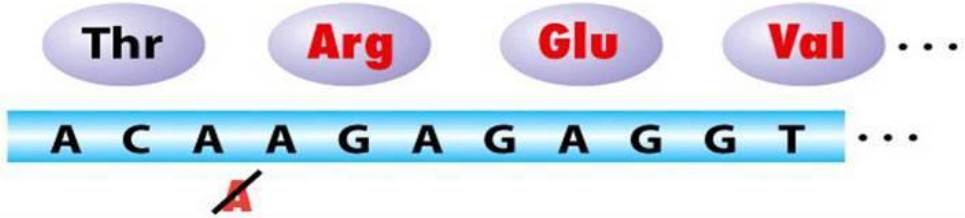
Frameshift Mutation: insertion or deletion of a nitrogen base

gene



Gene with insertion

Gene with deletion



Examples of Frameshift Mutations

- Tay Sachs: rare inherited disorder that progressively destroys nerve cells (neurons) in the brain and spinal cord.
- Cystic Fibrosis: causes mucus to be thick and sticky- can clogs the lungs, causing breathing problems and makes it easy for bacteria to grow.

57A–57D Note the prominent forehead, proptosis, hypertelorism, hooked nose and small jaw. The young boy in school uniform is the grandfather of 57C.

Think!

A frame shift mutation

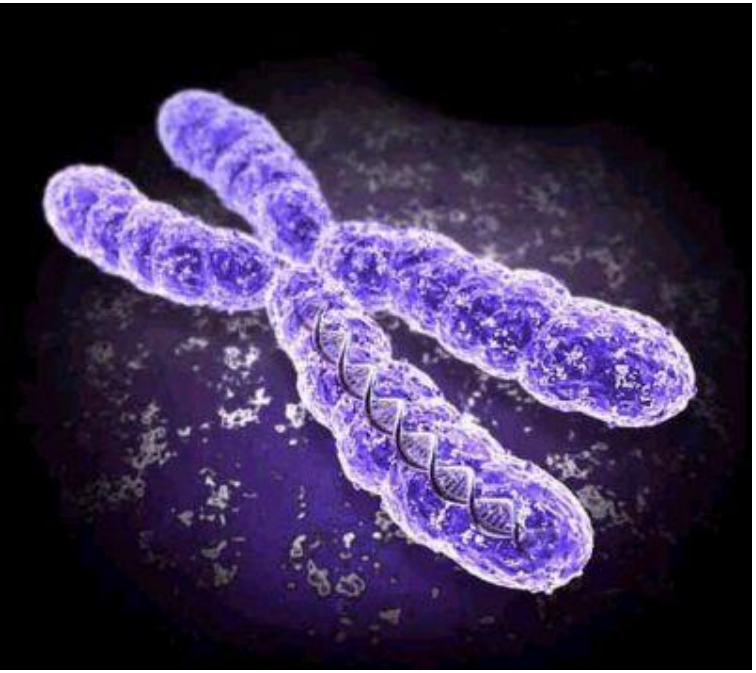
A) replaces one amino acid with another.

B) removes part of the protein.

C) introduces a section of amino acids not normally found.

D) joins two different proteins.

Chromosomal Mutation



Human X chromosomes with an expanded CGG/CCG Tract Express a Fragile site

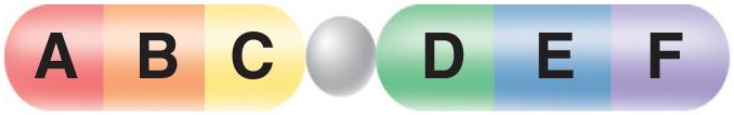
Chromosomal mutations

- **Chromosomes** break or are lost
- Broken chromosomes may rejoin incorrectly
- **Almost always lethal (kills)** when it occurs in a zygote (fertilized egg that will become a baby)
- Results in **major** changes to proteins produced

4 Types of Chromosomal Mutations

A. Deletion - **loss** of all or part of chromosome
B. Duplications - **extra** copies of a chromosome
C. Inversions - **reverse** the direction of chromosomes
D. Translocation - when part or a chromosome **breaks** off and **reattaches** to another

Chromosomal Mutation



Original chromosome

Deletion

Duplication

Translocation

Inversion