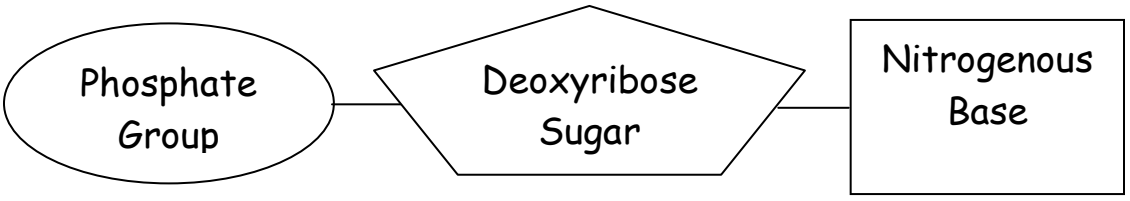
DNA: The Molecule of Heredity

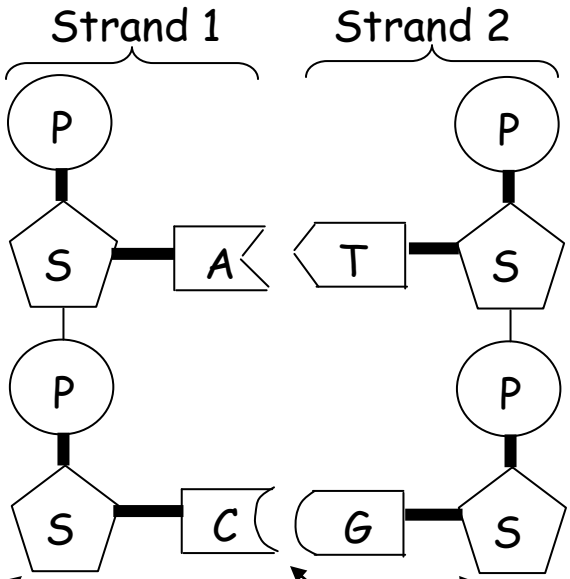
DNA

- Deoxyribonucleic acid
- Is a type of nucleic acid
- What chromosomes (and genes) are made of
- Made up of repeating nucleotide subunits
- 1 nucleotide looks like:



4 types: Adenine (A)
Guanine (G)
Cytosine (C)
Thymine (T)

- 2 strands so bases can pair up
  - A binds T only
  - C binds G only

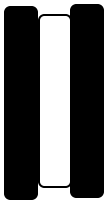


Phosphates + sugars on the outside

Bases on the inside (Bases fit like puzzle pieces)

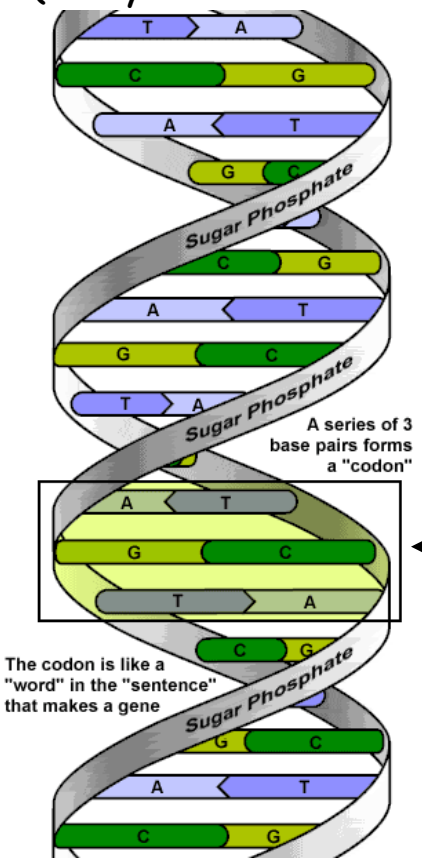
Remember

DNA is like an Oreo



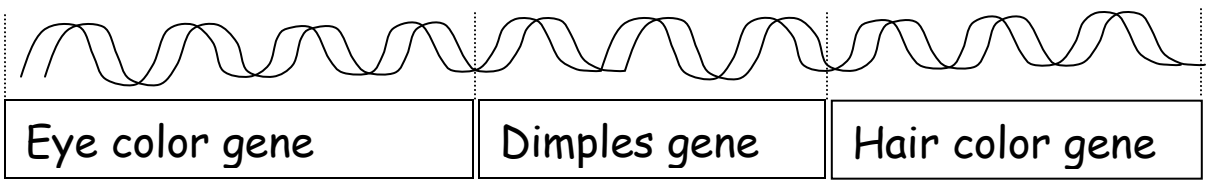
Phophates + sugars = cookies
Bases = cream filling

- Shape is a double helix
  - Double helix: 2 spirals wound around each other
  - Rosalind Franklin took an X-ray photo of DNA
  - James Watson and Francis Crick interpreted the photo and discovered the double helix structure (They won the Nobel Prize)



Codon: Group of 3 bases

- Genes: stretch of DNA that codes for a trait
  - The code is the order of the bases (letters)
  - Genes are hundreds or thousands of bases long



Chargaff's Rule

- In DNA, the amount of *A* = the amount of *T*
  the amount of *C* = the amount of *G*

DNA is complementary

- Complementary: bases on one strand match up with the bases on the other strand (*A*-*T* and *G*-*C*)
- Example: Strand 1- *ATG GGC CTA*
  Strand 2- *TAC CCG GAT*

Replication

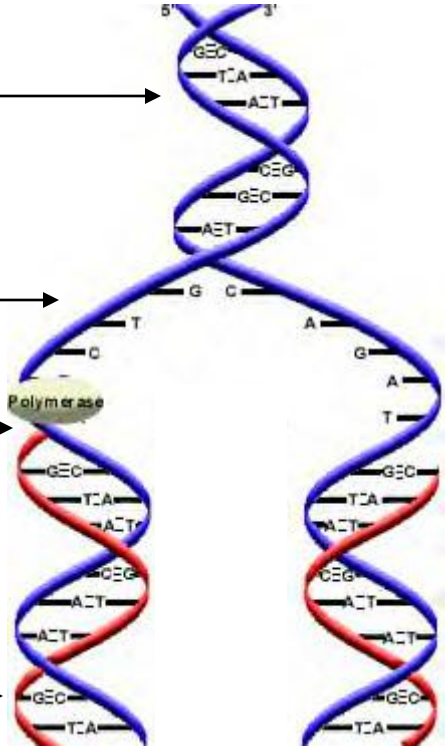
- Process by which new copies of DNA are made
- Happens to duplicated chromosomes before mitosis and meiosis
- **Semi-conservative replication**: Each new piece of DNA is made up of 1 old strand and 1 new strand

Original double-stranded DNA

The enzyme **helicase** unwinds and unzips the DNA

Using each original strand as a template, the enzyme **DNA polymerase** assembles a new strand

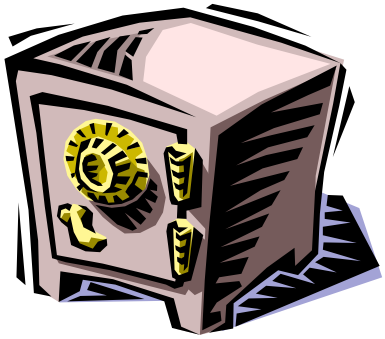
Two copies of double-stranded DNA, each of which is $\frac{1}{2}$ old + $\frac{1}{2}$ new



DNA never ever leaves the nucleus

- DNA is the master copy of the directions a cell needs to live so it needs to be protected

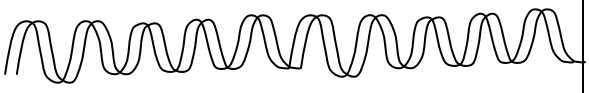
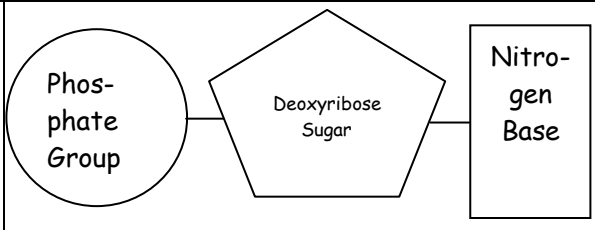
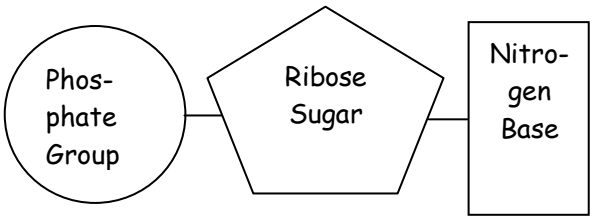
DNA in the nucleus is safe



But DNA in the cytoplasm can be destroyed

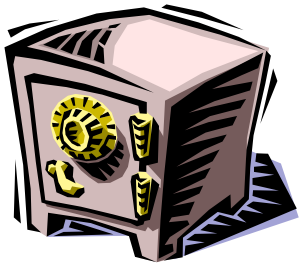
RNA is a copy of DNA that goes out into the cytoplasm to tell the cell what to do in order to stay alive

- RNA: ribonucleic acid
- You can always make more RNA so it's ok if it gets destroyed (You can't make more DNA!!!)

	DNA	**RNA**
How many strands?	2 	1 
Nucleotide subunit	 Deoxyribose sugar	 Ribose sugar
Bases	Thymine (T) Adenine (A) Guanine (G) Cytosine (C) T – A G – C	Uracil (U) Adenine (A) Guanine (G) Cytosine (C) U – A G – C

Transcription

- Definition: RNA is made from 1 gene in DNA
- The type of RNA made is called mRNA (messenger RNA) because it sends a message from DNA to the cytoplasm



DNA safe in the nucleus

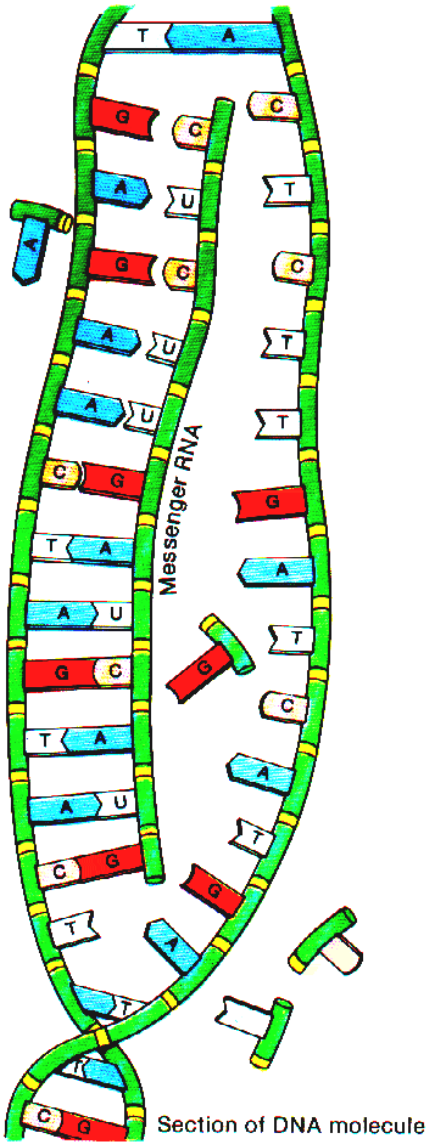
Uses mRNA

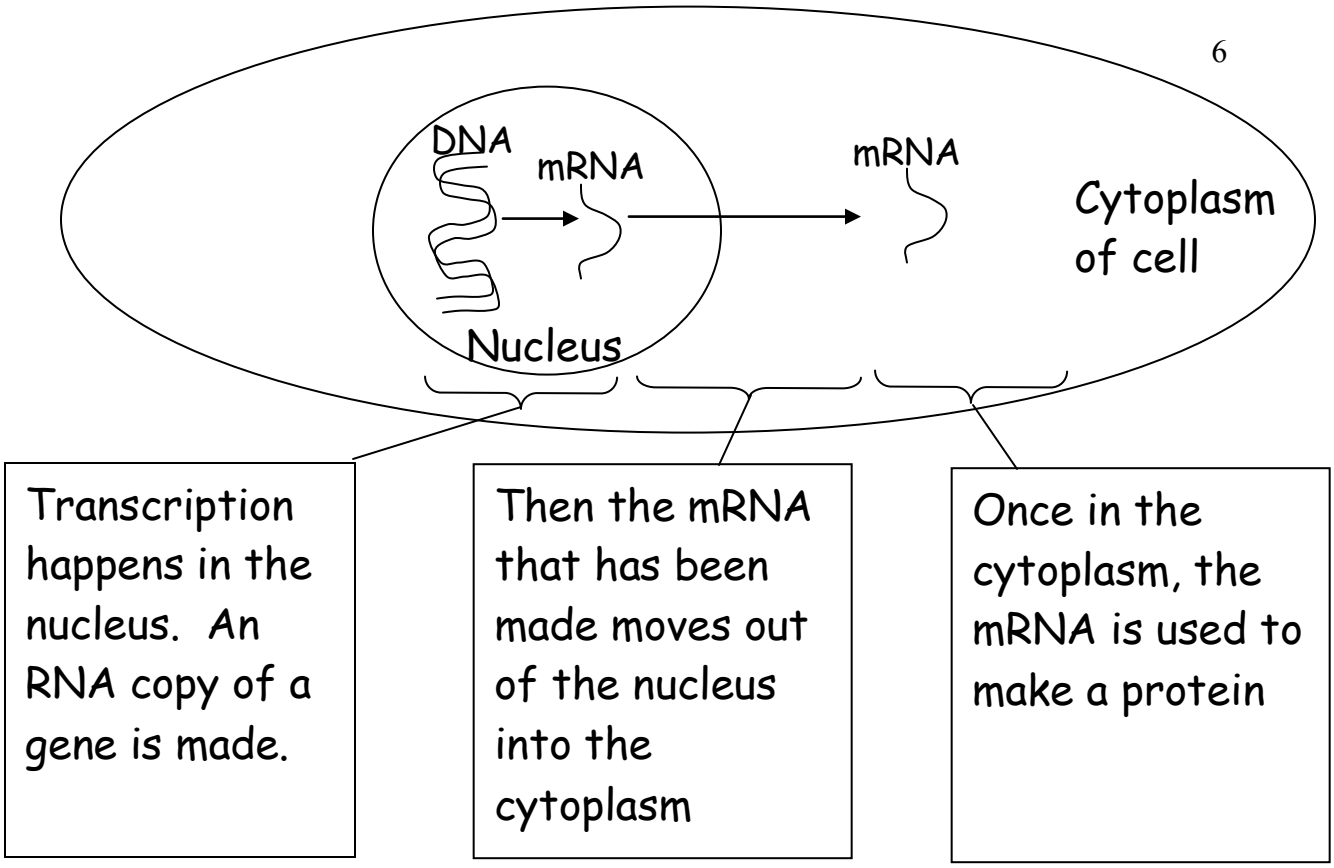
To send a message to the cytoplasm

- Transcription
  - Unzip one gene in DNA
  - Match up bases to <u>one</u> side of a gene in DNA
  - mRNA detaches from the DNA
  - mRNA moves out of the nucleus and into the cytoplasm

DNA: *GAG AAC TAG TAC*
RNA: *CUC UUG AUC AUG*

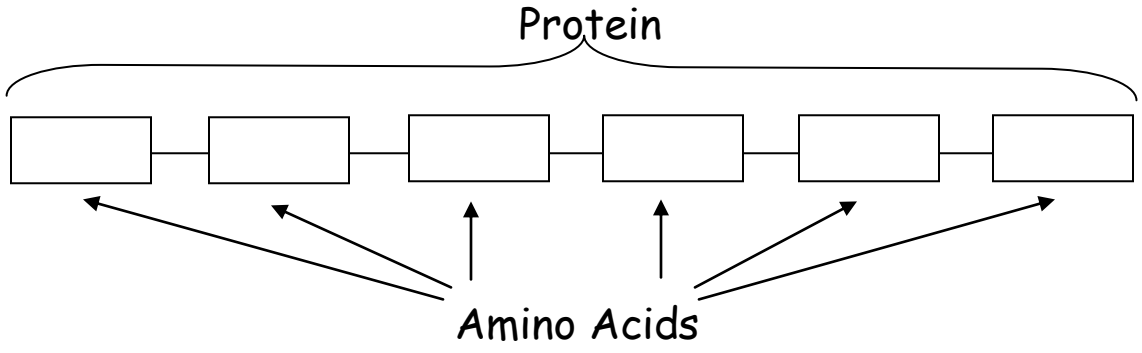
For figuring out RNA:
A binds U
C binds *G*





How does mRNA tell the cell what to do?

- mRNA is a message that codes for a protein
- Proteins are made in the cytoplasm and then work to keep the cell alive
- Translation (protein synthesis): Process of making a protein
- Proteins are made up of amino acids (small building blocks)
- There are 20 different types of amino acids



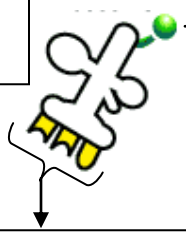
Process of Translation

1. mRNA moves out of nucleus and into cytoplasm

2. mRNA attaches to a ribosome

3. Transfer RNA (tRNA) decodes the mRNA and brings amino acids to build up the protein

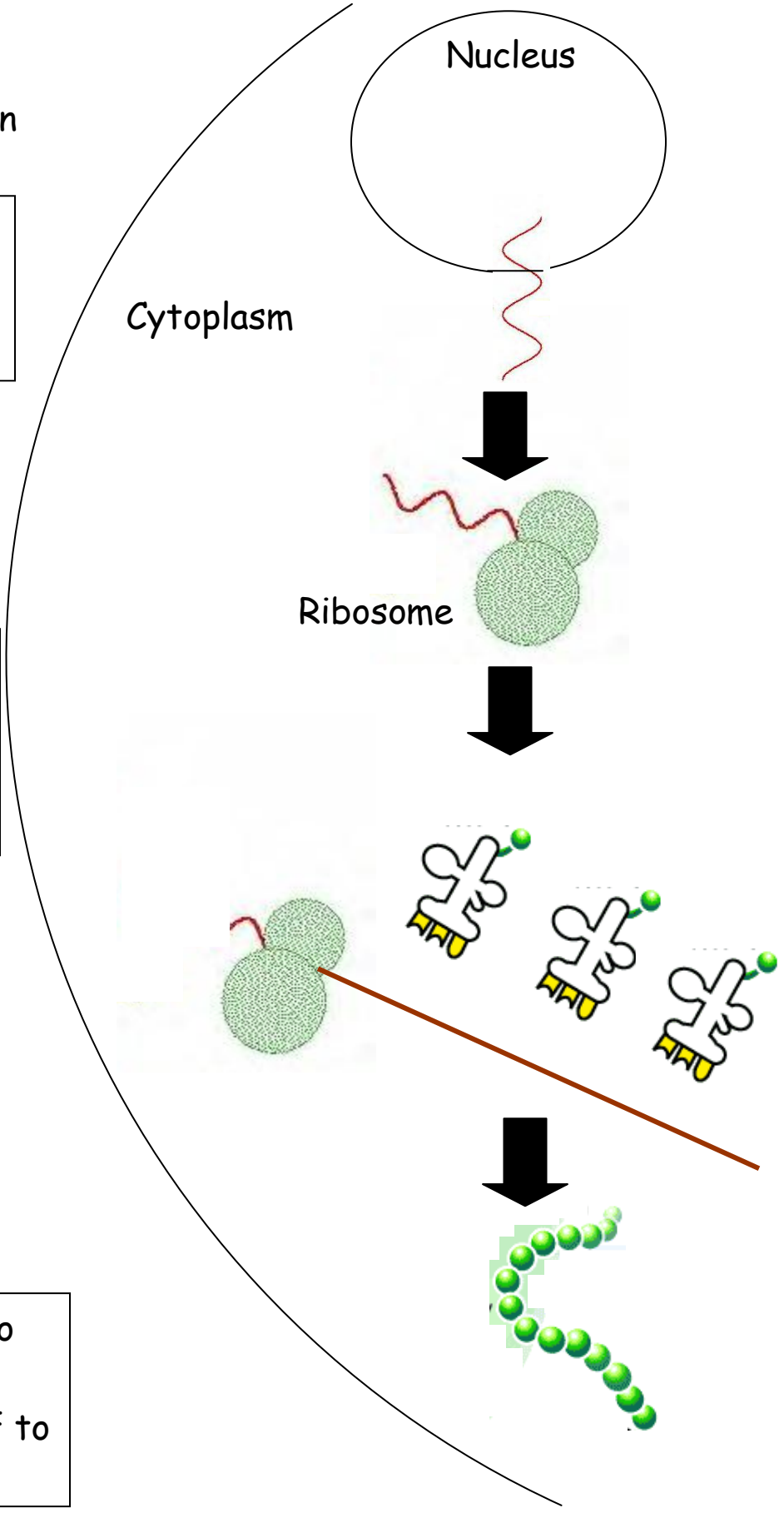
tRNA



Amino acid

Anticodon (3 bases on tRNA): Matches up to codons on mRNA

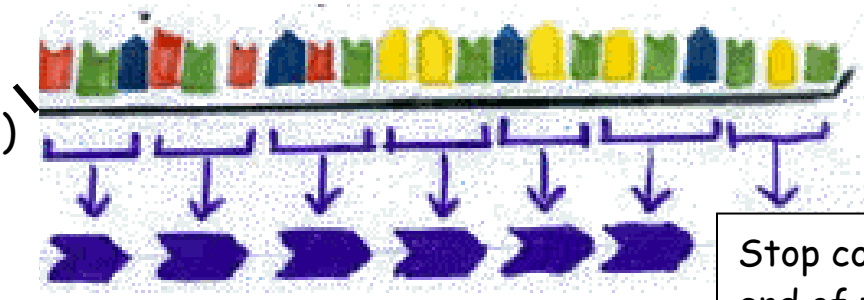
4. Protein (chain of amino acids) detaches from ribosome and goes off to work in the cell



Genetic Code

- Code that matches codons in mRNA to amino acids on tRNAs

mRNA codons (3 bases)



Amino acids

Stop codon – codes for the end of the mRNA (no amino acid added)

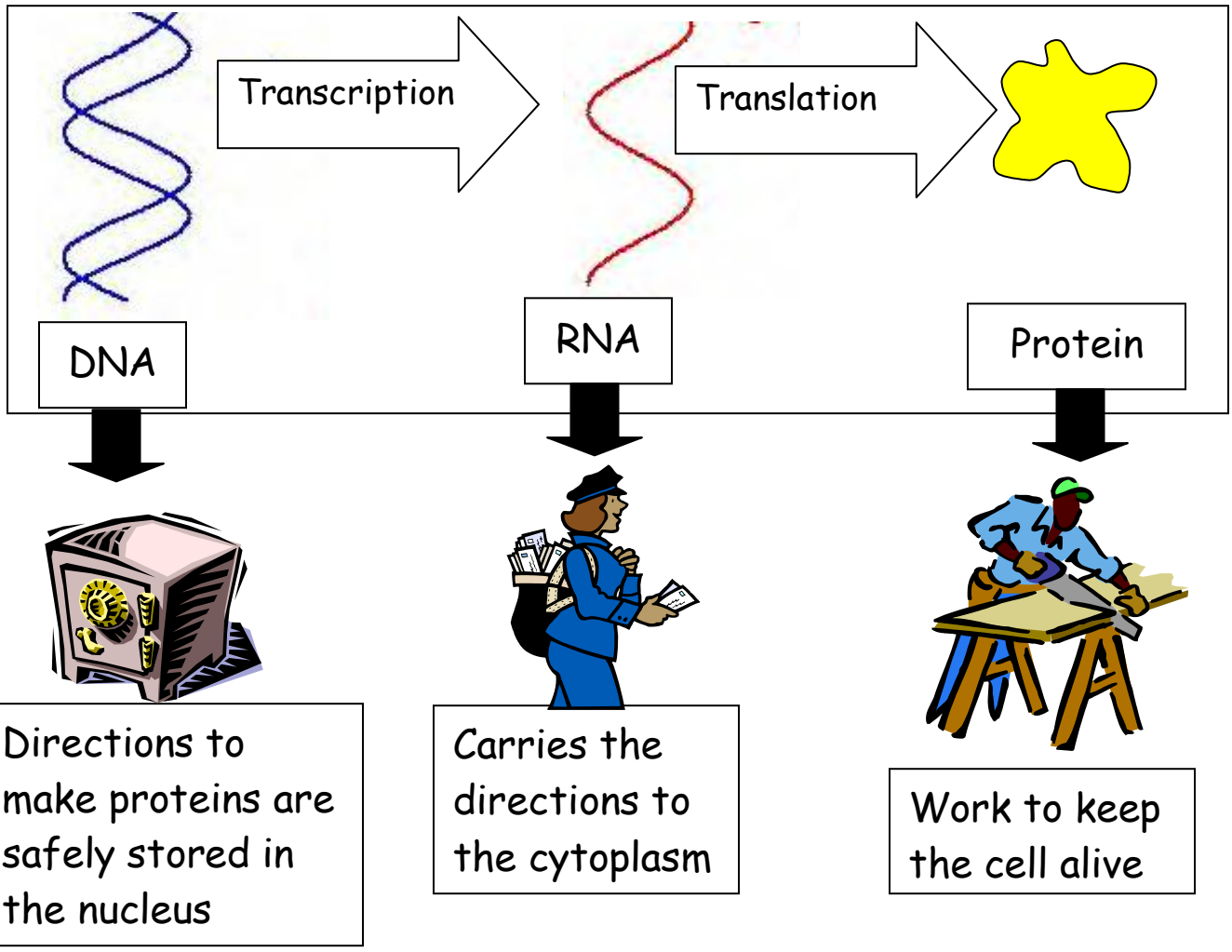
Second base

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

1. Read your mRNA codon → ACU
2. Find 1st base on the left, 2nd base on the top, 3rd base on the right. Find where they all cross in the chart.
3. Read your amino acid. → Threonine

Different codons code for different amino acids!!!

Central dogma of molecular biology



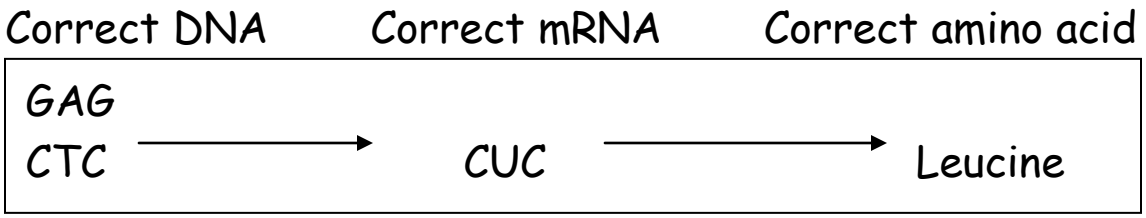
Mutation

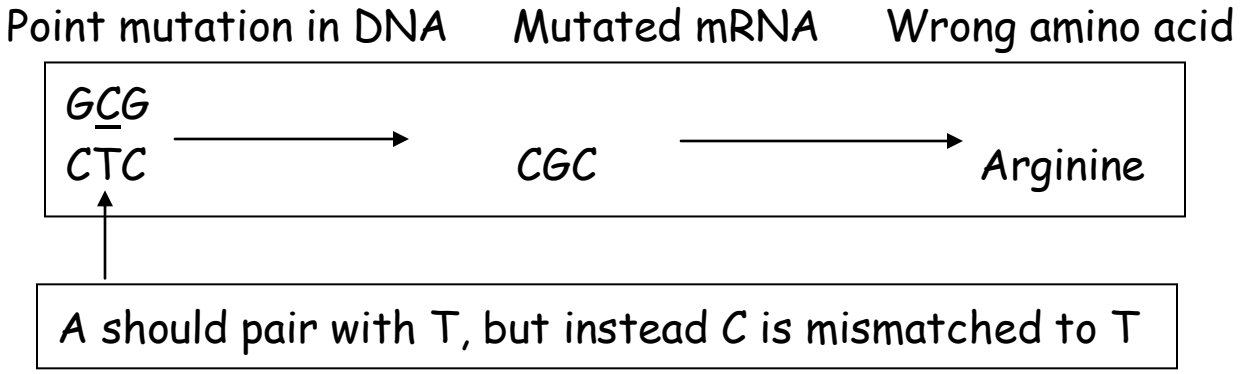
- a change in the DNA sequence
- It's a mistake that's made during replication or transcription
- can be harmful: diseases or deformities
  helpful: organism is better able to survive
  neutral: organism is unaffected
- if a mutation occurs in a sperm or egg cell, that mutation is passed onto offspring

- if a mutation occurs in a body cell, that mutation affects only the organism and is not passed onto offspring

Types of mutations

1. Point mutations: Bases are mismatched
    - Harmful when: a mistake in DNA is carried into mRNA and results in the wrong amino acid





    - Not harmful when: a mistake in DNA is carried into mRNA but still results in the correct amino acid

2. Frameshift mutations: bases are inserted or deleted
    - Are usually harmful because a mistake in DNA is carried into mRNA and results in many wrong amino acids

Correct DNA:	ATA TAT	CCG GGC	TGA ACT
Correct mRNA:	UAU	GGC	ACU
Correct amino acids:	Tyrosine	Glycine	Threonine

Extra inserted base shifts how we read the codons (3 bases), which changes the amino acids

Frameshift mutation in DNA:	ATG TAC	ACC TGG	GTG CAC	A T
Mutated mRNA:	UAC	UGG	CAC	U
Wrong amino acids:	Tyrosine	Tryptophan	Histadine	

3. Chromosomal mutations

- chromosomes break or are lost during mitosis or meiosis
- broken chromosomes may rejoin incorrectly
- almost always lethal when it occurs in a zygote

Causes of mutations

- mutagens: anything that causes a change in DNA
- examples: X rays, UV light, nuclear radiation, asbestos, cigarette smoke