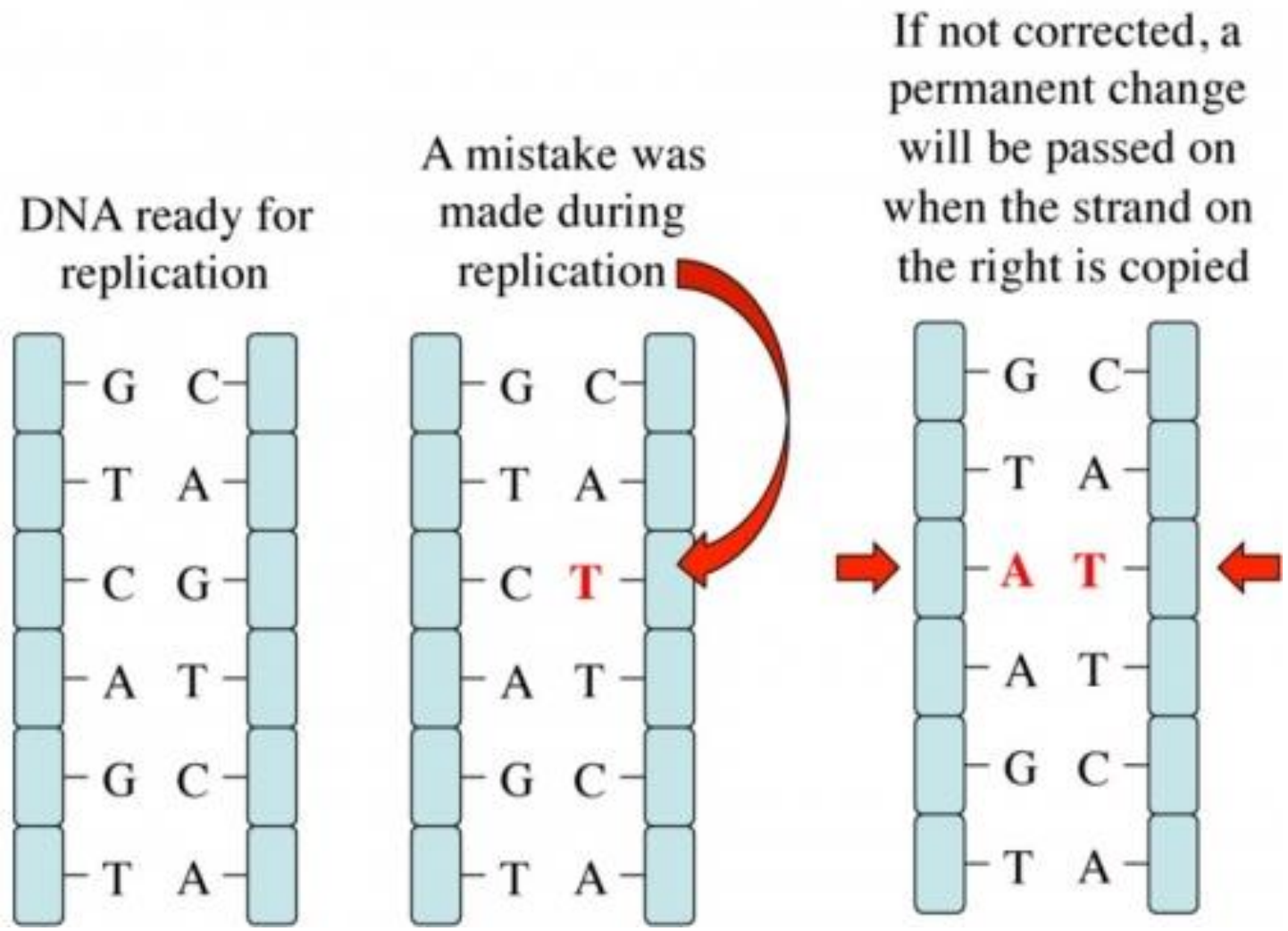
Telephone Game

- Every time a DNA makes a copy (spreading of a message), mutations can happen (mistakes in a message)

Mistakes in DNA

- Cells make mistakes during replication and transcription
- Most often these mistakes are fixed by DNA repair enzymes
- Some mistakes persist and are passed to daughter cells, called mutations.



Causes of Mutations

- Mutations can happen spontaneously or be caused by environmental factors
- **Mutagens**: certain chemicals or radiation that can cause DNA damage by causing bases to mispair and bond with the wrong base

  Examples:
  - Physical Mutagens: radiation (UV rays, X rays, & gamma rays)
  - Chemical Mutagens: Benzene (chemical in gasoline)
  - Biological Mutagens: viruses

Mutation

- A permanent change that occurs in a cell's DNA
- Can occur at the gene level or chromosome level

Gene Mutations

(3 types)

1. Point mutation
2. Insertion
3. Deletion

Chromosome Mutations

(4 types)

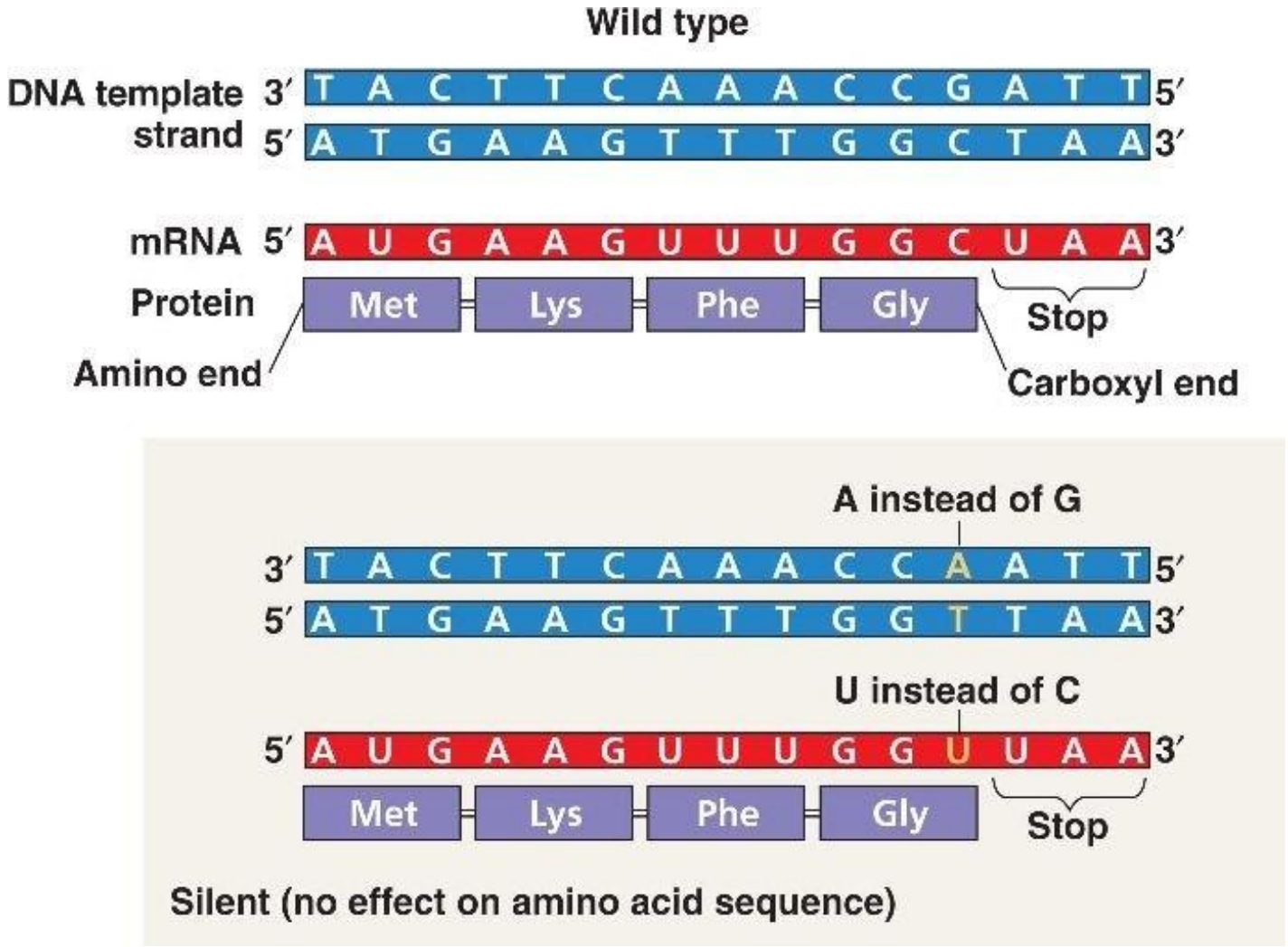
1. Deletion
2. Duplication
3. Inversion
4. Translocation

Gene Level Mutations
Point Mutations

- **Substitution**: a change in just one base pair
  1. **Silent Mutation**: amino acid is NOT changed
  2. **Missense Mutation**: amino acid is changed
  3. **Nonsense Mutation:** amino acid is changed to a STOP codon

Silent Mutation

No change to the amino acid sequence / no change to protein built

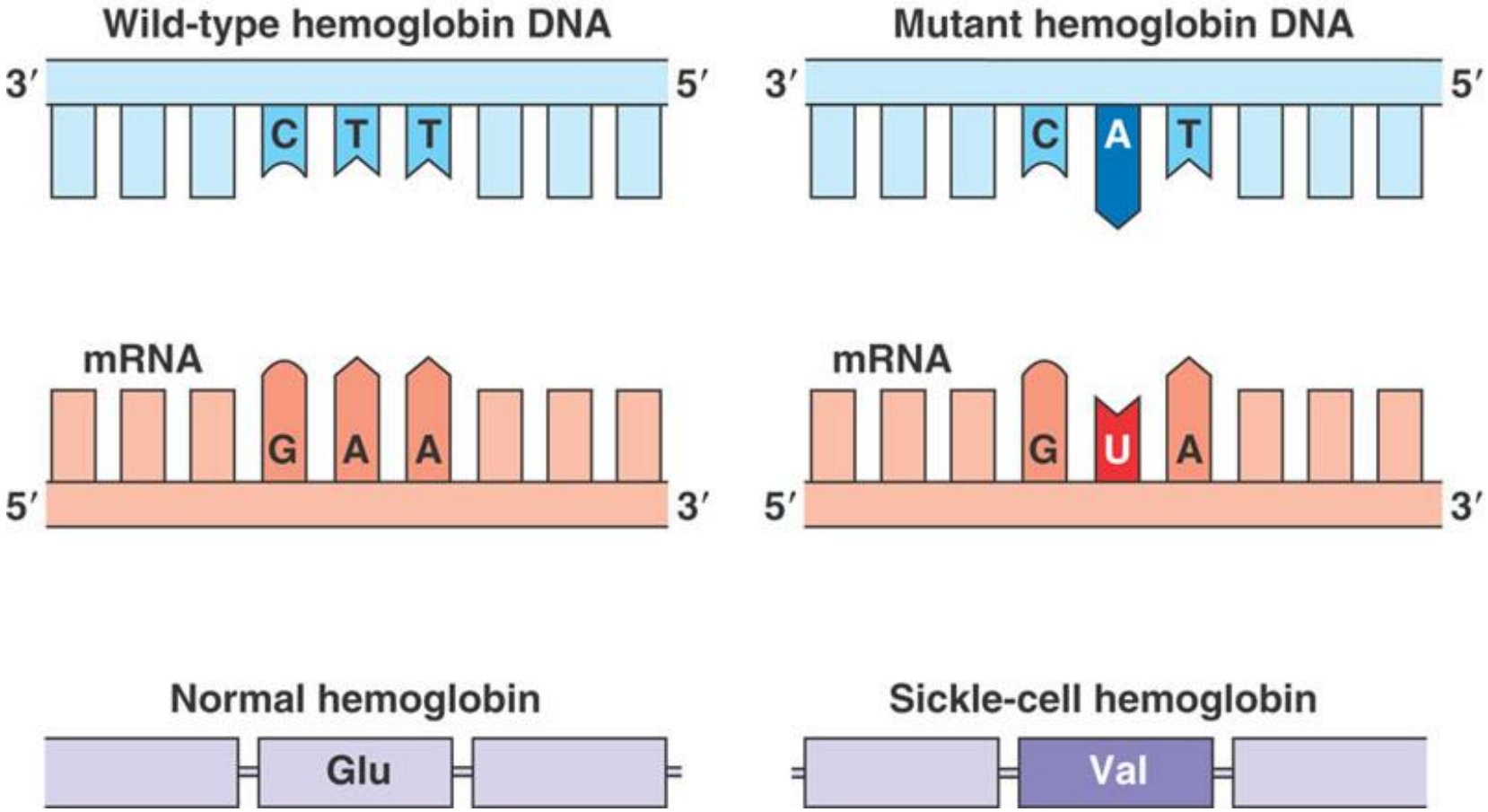


Codons Found in Messenger RNA

First Base	Second Base U	Second Base C	Second Base A	Second Base G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Missense Mutation

Disease Example: Sickle cell anemia; Achondroplasia (dwarfism)

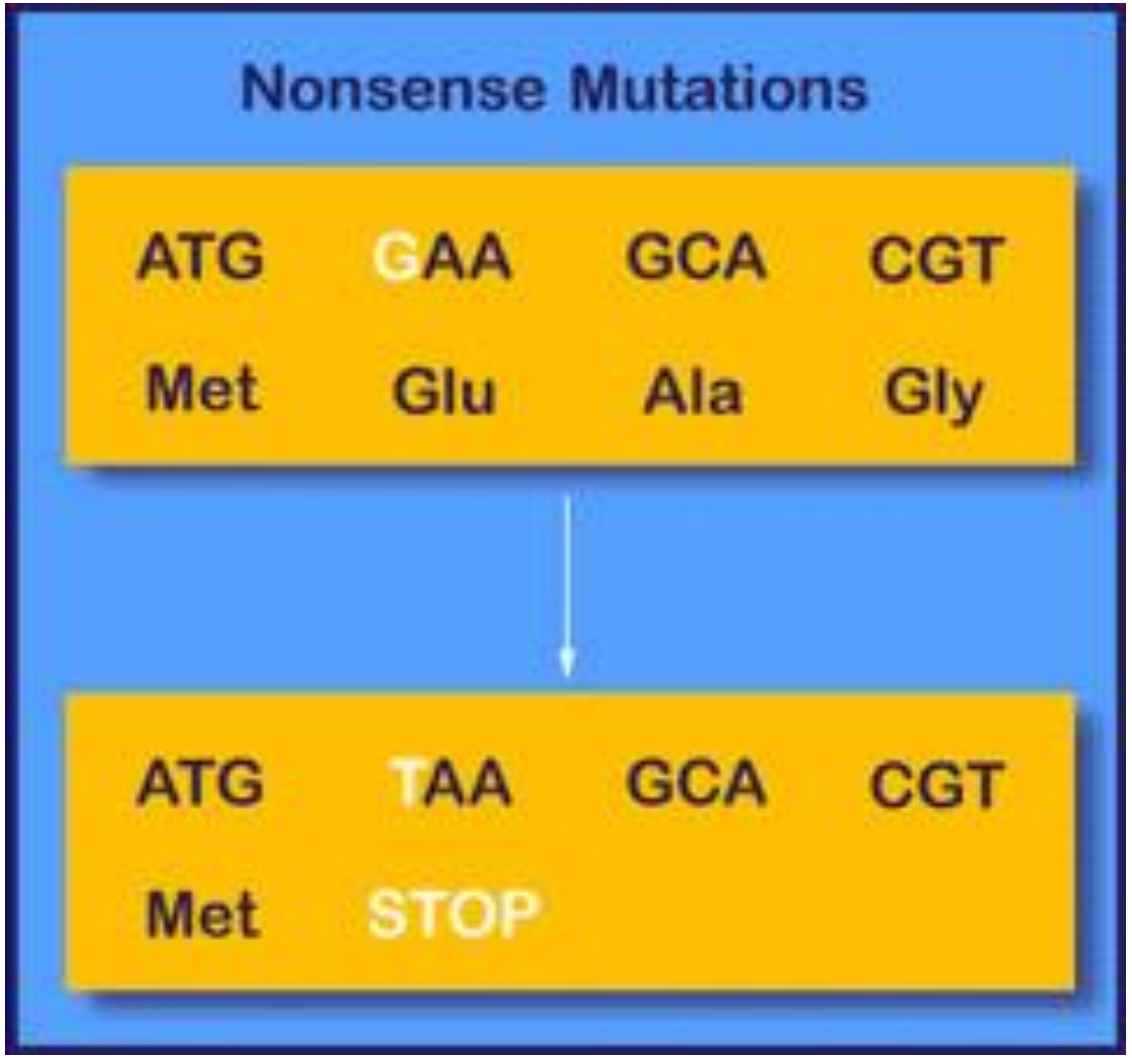


Codons Found in Messenger RNA

First Base	Second Base U	Second Base C	Second Base A	Second Base G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Nonsense Mutation

Disease Example: Muscular Dystrophy



Codons Found in Messenger RNA

First Base	Second Base: U	Second Base: C	Second Base: A	Second Base: G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Point Mutations and Their Effects

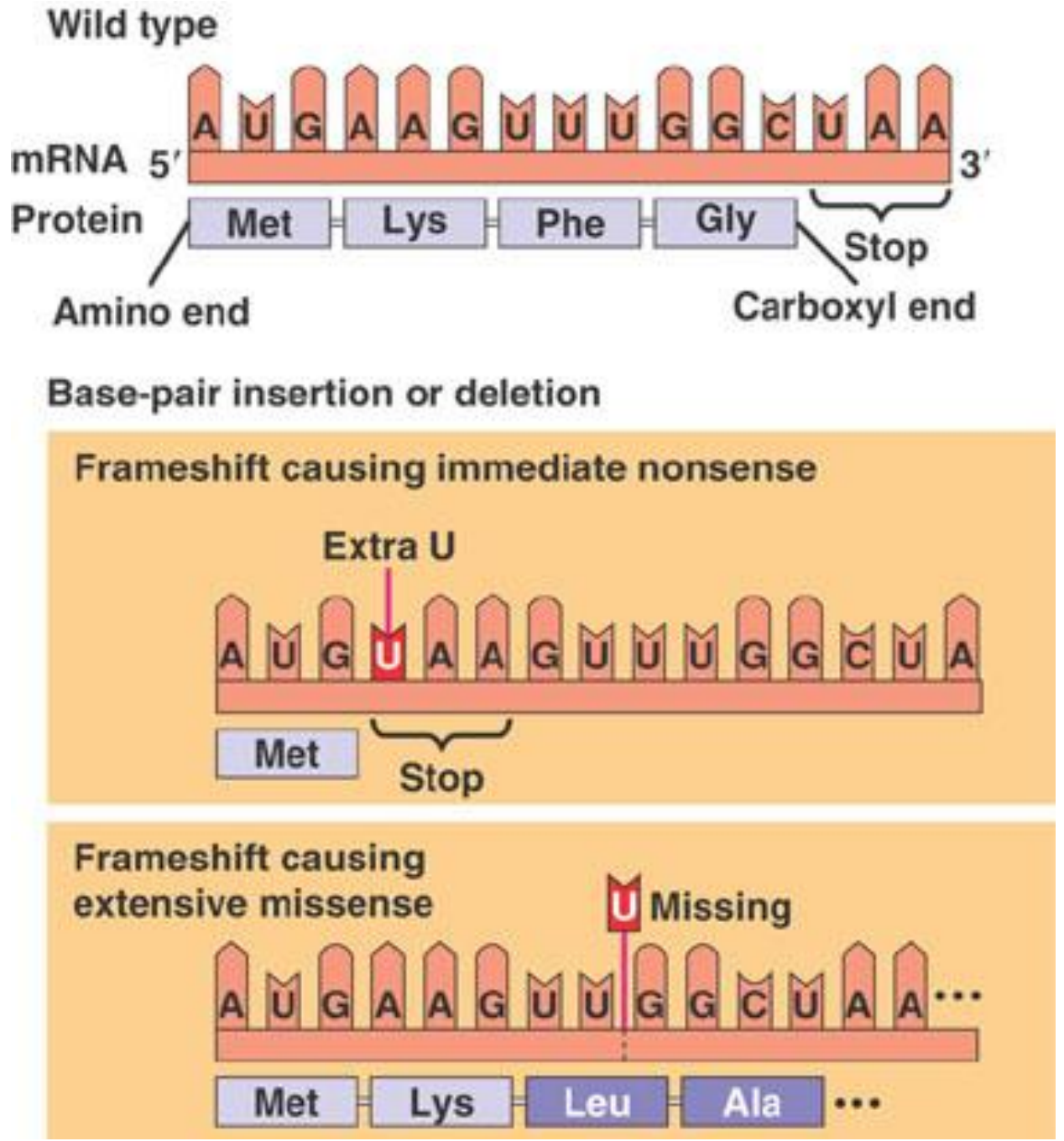
Type	Description	Example	Effect
Silent	mutated codon codes for the same amino acid	CAA (glutamine) → CAG (glutamine)	none
Missense	mutated codon codes for a different amino acid	CAA (glutamine) → CCA (proline)	variable
Nonsense	mutated codon is a premature stop codon	CAA (glutamine) → UAA (stop) usually	serious

Frameshift Mutations

- Causes the reading frame to shift to the left or the right
- **Insertion**:

  Addition of a nucleotide
- **Deletion**:

  Removal of a nucleotide



Examples of Gene Mutations

THE FAT CAT ATE THE RAT

Normal protein or sentence

Each word represents an amino acid in a PROTEIN (SENTENCE)

THE HAT CAT ATE THE RAT

Sentence or Protein is still readable.

THE _ATC ATA TET HER AT

Sentence makes No sense due to Frame Shift

THE FFA TCA TAT ETH ERA T

Sentence makes NO sense due to Frame Shift

	Mutations	
Mutation Type	**Analogy Sentence**	**Example of Associated Disease**
Normal	THE BIG FAT CAT ATE THE WET RAT	
Missense (substitution)	THE BIZ FAT CAT ATE THE WET RAT	Achondroplasia: improper development of cartilage on the ends of the long bones of arms and legs resulting in a form of dwarfism
Nonsense (substitution)	THE BIG RAT	Muscular dystrophy: progressive muscle disorder characterized by the progressive weakening of many muscles in the body
Deletion (causing frameshift)	THB IGF ATC ATA TET HEW ETR AT	Cystic fibrosis: characterized by abnormally thick mucous in the lungs, intestines, and pancreas
Insertion (causing frameshift)	THE BIG ZFA TCA TAT ETH EWE TRA	Crohn's disease: chronic inflammation of the intestinal tract, producing frequent diarrhea, abdominal pain, nausea, fever, and weight loss
Duplication	THE BIG FAT FAT CAT ATE THE WET RAT	Charcot-Marie-Tooth disease (type 1A): damage to peripheral nerves leading to weakness and atrophy of muscles in hands and lower legs
Expanding mutation (tandem repeats) **Generation 1** **Generation 2** **Generation 3**	THE BIG FAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT CAT CAT CAT ATE THE WET RAT	Huntington's disease: a progressive disease in which brain cells waste away, producing uncontrolled movements, emotional disturbances, and mental deterioration

ACGAAATACAGACAT

Determine what type of mutation occurred:

ACGAAATAGAGACAT — **Substitution (point mutation)**

ACAAATACAGACAT — **Deletion (frameshift mutation)**

ACGAAATACAGGACAT — **Insertion (frameshift mutation)**

Practice gene mutations

- Use your mRNA codon chart/ wheel to answer these questions.

....TACGCGATATGGCGCAGGATC....(template)
....ATGCGCTATACCGCGTCCTAG....

What "protein" will the template side produce?

Change any base (letter) in the template DNA to produce a different sequence and report the "protein" (AA sequence).
Sequence:
Protein:

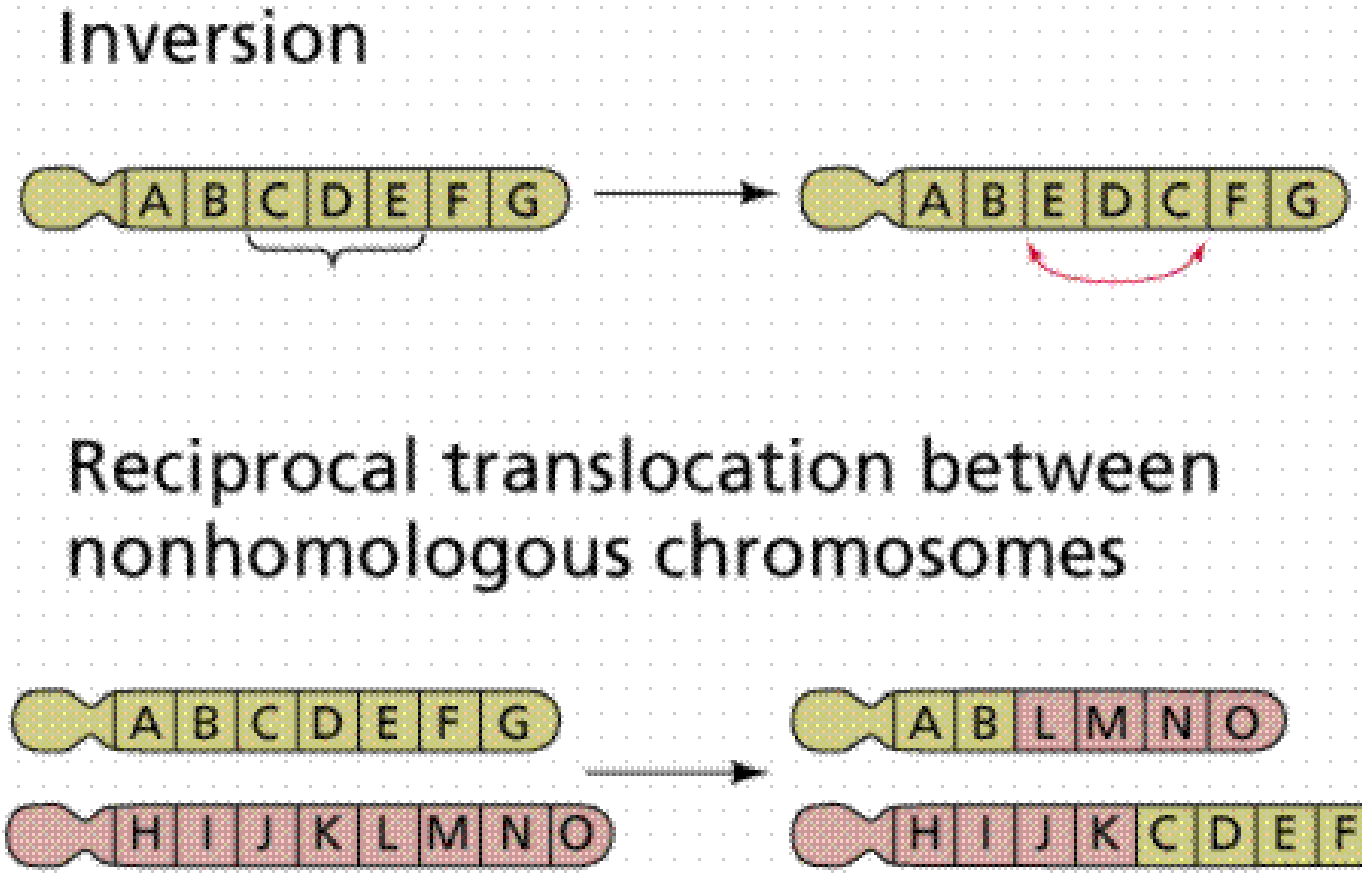
Insert or delete a base (letter) in the template DNA and report the "protein".
Sequence:
Protein:

Make one base change to the DNA that will create a shorter "protein" and report the "protein".
Sequence:
Protein:

Make a base (letter) change to the DNA that will create the same "protein".
Sequence:

Chromosomal Mutations

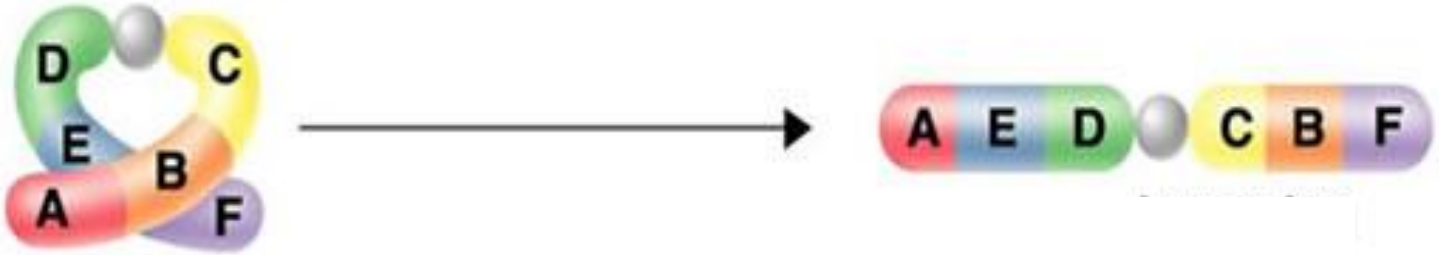
- Piece of a chromosome can be broken off, duplicated, or moved to another chromosome
- More DNA is affected by chromosomal mutations than gene mutations



Types of Chromosomal Mutations

<u>Deletion</u>: loss of all or part of a chromosome

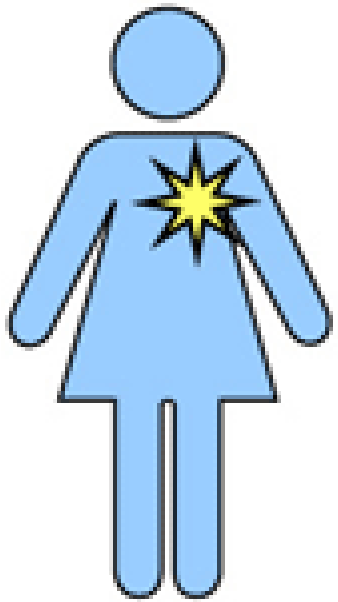
<u>Duplication</u>: a segment of a chromosome is repeated



<u>Inversion</u>: chromosome sections become disoriented

<u>Translocation</u>: part of one chromosome attaches to a non-homologous chromosome

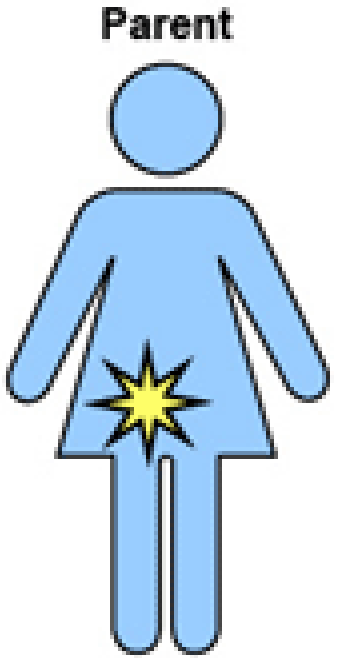
Mutations in a **somatic (body)** cell CANNOT be passed to offspring!



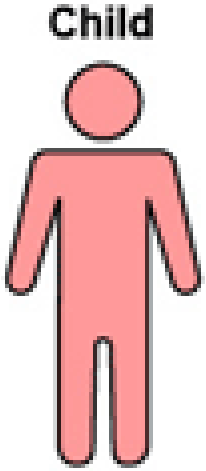
Nonheritable

Mutation in tumor only
(for example, breast)

Mutations in **gametes CAN** be passed to offspring!



Heritable



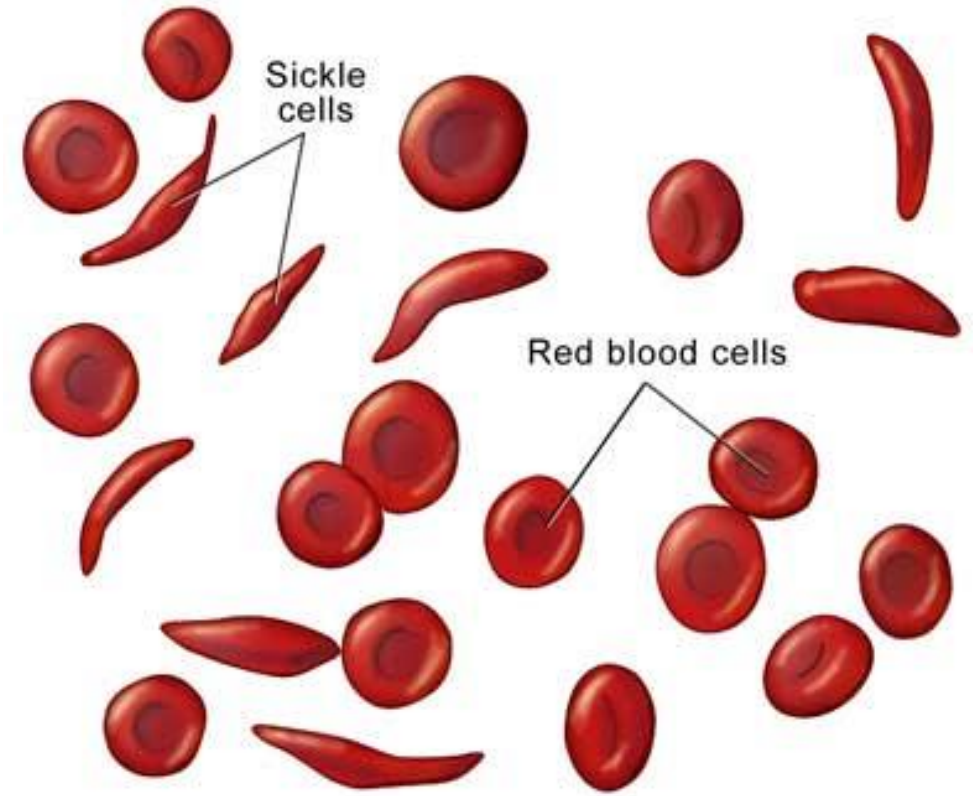
Mutation in
egg or sperm

All cells
affected in
offspring

Adapted from the National Cancer Institute and the American Society of Clinical Oncology

Mutations → Genetic Disorders

- Mutations can lead to genetic disorders
- Can change both the <u>folding</u> and stability of the protein
- Ex. Sickle Cell Anemia (caused by a substitution mutation)



- Amoeba Sisters - Mutations