Microbyte:

GENETIC MUTATIONS

(instructor use) - version: 03.12.21

Changes in the genetic code

- **Mutation:** Any change to the DNA sequence in the genome
  - Can be detrimental or beneficial to the organism
- Causes of mutations:
  - **Spontaneous mutation:** A random change arising from errors in DNA replication
  - **Induced mutations:** A change induced by exposure to a mutagens (e.g. radiation)

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- Causes of mutations:
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  - **Induced mutations:** A change induced by exposure to a mutagens (e.g. radiation)
- Types of mutations:
  - **Point mutation:** affect only a single nucleotide of a gene; involve addition, deletion, or substitution of a single nucleotide.
  - Substitution point mutations can result in no change to the amino acid *(silent),* a change to the amino acid *(missense),* or a premature stop codon *(nonsense).*
  - Insertion or deletion point mutations can result in frameshift mutations; however, not all frameshift mutations are point mutations
  - **Frameshift mutation:** one or more bases are inserted or deleted. Insertions and deletions will *shift* the *frame* of codons read during translation and may lead to a completely different chain of amino acids being produced.

DNA coding strand:	ATGGGAACTTAG	original
DNA coding strand:	ATGGGTACTTAG	point mutation *(silent)*

Separate into triplets, add the template sequence, then transcribe and translate:

DNA coding strand:	ATG GGA ACT TAG	original
DNA template strand:	TAC CCT TGA ATC	
mRNA transcript:	AUG GGA ACU UAG	
amino acid sequence:	Met Gly Thr Stop	
DNA coding strand:	ATG GGT ACT TAG	point mutation *(silent)*
DNA template strand:	TAC CCA TGA ATC	
mRNA transcript:	AUG GGU ACU UAG	
amino acid sequence:	Met Gly Thr Stop	

DNA coding strand:	ATGGGAACTTAG	original
DNA coding strand:	ATGGGACCTTAG	point mutation *(missense)*

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DNA template strand:	TAC CCT TGA ATC	
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mRNA transcript:	AUG GGA CCU UAG	
amino acid sequence:	Met Gly Pro Stop	

DNA coding strand:	ATGGGAACTTAG	original
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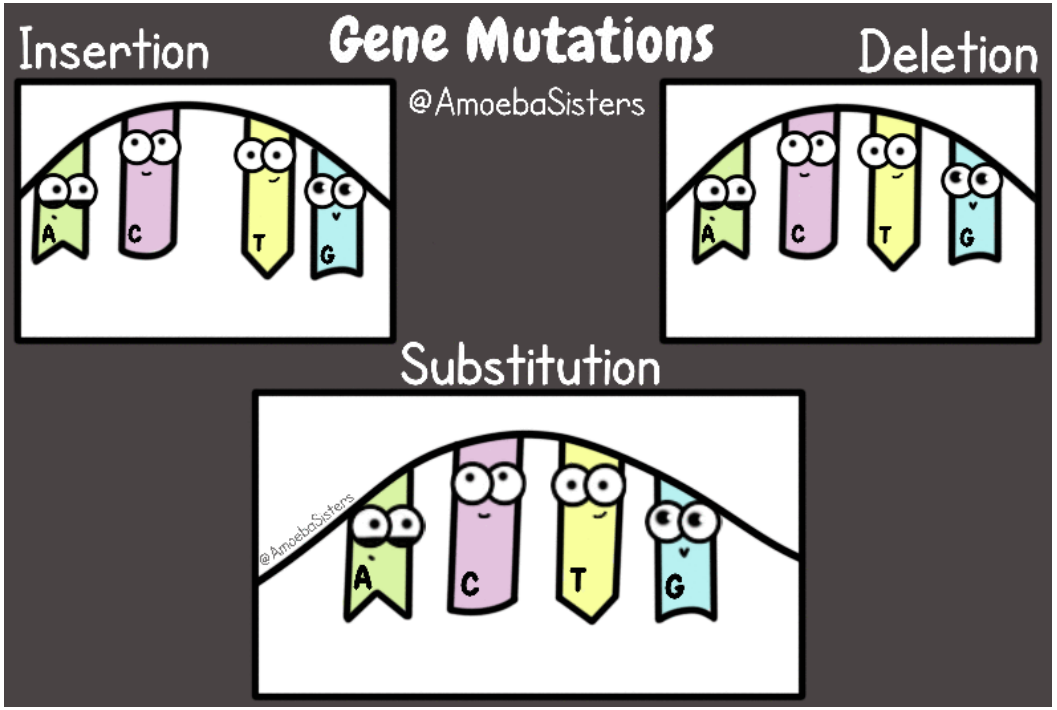
DNA template strand:	TAC ACT TGA ATC	
mRNA transcript:	AUG UGA ACU UAG	
amino acid sequence:	Met Stop	

Mutations



Point mutations involving the *substitution* of a single nucleotide in the DNA sequence result in a different mRNA codon read during translation and lead to one of three outcomes:

silent mutation: the amino acid stays the same
missense mutation: a change in amino acid
nonsense mutation: a premature stop codon

gif credit: Amoeba Sisters

Reading frames and frameshift mutations

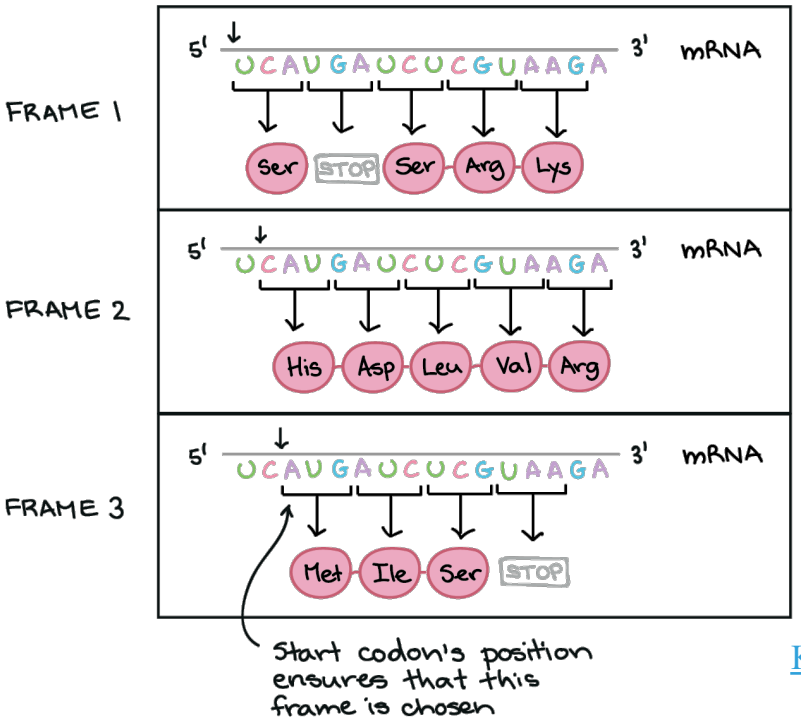


image credit: Khan Academy

- The **reading frame** references how the sequence of an mRNA transcript is divided into codons during translation.
- Recall that:

one triplet → one codon → one amino acid

- So, ultimately the reading frame of a gene is specified in the triplet nucleotides of the DNA sequence.

- When a nucleotide(s) are inserted or deleted from the DNA sequence of a gene, the reading frame for that gene *shifts* - hence: **frameshift mutation**.
- A frameshift mutation results in the mRNA transcript specifying a different set of codons and when the ribosome reads that mutated transcript it will translate an entirely different amino acid sequence.

If a single nucleotide is inserted or deleted the frameshift mutation is also a *point mutation*

DNA coding strand:	ATGGGAACTTAG	original
DNA coding strand:	ATGGTGAACTTAG	frameshift insertion *(point)*

Separate into triplets, add the template sequence, then transcribe and translate:

DNA coding strand:	ATG GGA ACT TAG	original
DNA template strand:	TAC CCT TGA ATC	
mRNA transcript:	AUG GGA ACU UAG	
amino acid sequence:	Met Gly Thr Stop	
DNA coding strand:	ATG GTG AAC TTA G	frameshift insertion *(point)*
DNA template strand:	TAC CAC TTG AAT C	
mRNA transcript:	AUG GUG AAC UUA G	
amino acid sequence:	Met Val Asn Leu	

DNA coding strand:	ATGGGAACTTAG	original
DNA coding strand:	ATGGGAACTTAG	frameshift deletion *(point)*

Separate into triplets, add the template sequence, then transcribe and translate:

DNA coding strand:	ATG GGA ACT TAG	original
DNA template strand:	TAC CCT TGA ATC	
mRNA transcript:	AUG GGA ACU UAG	
amino acid sequence:	Met Gly Thr Stop	
DNA coding strand:	ATG GAA CTT AG	frameshift deletion *(point)*
DNA template strand:	TAC CTT GAA TC	
mRNA transcript:	AUG GAA CUU AG	
amino acid sequence:	Met Glu Leu	

DNA coding strand:	ATGGGAACTTAG	original
DNA coding strand:	ATGGGGTAACTTAG	frameshift insertion

Separate into triplets, add the template sequence, then transcribe and translate:

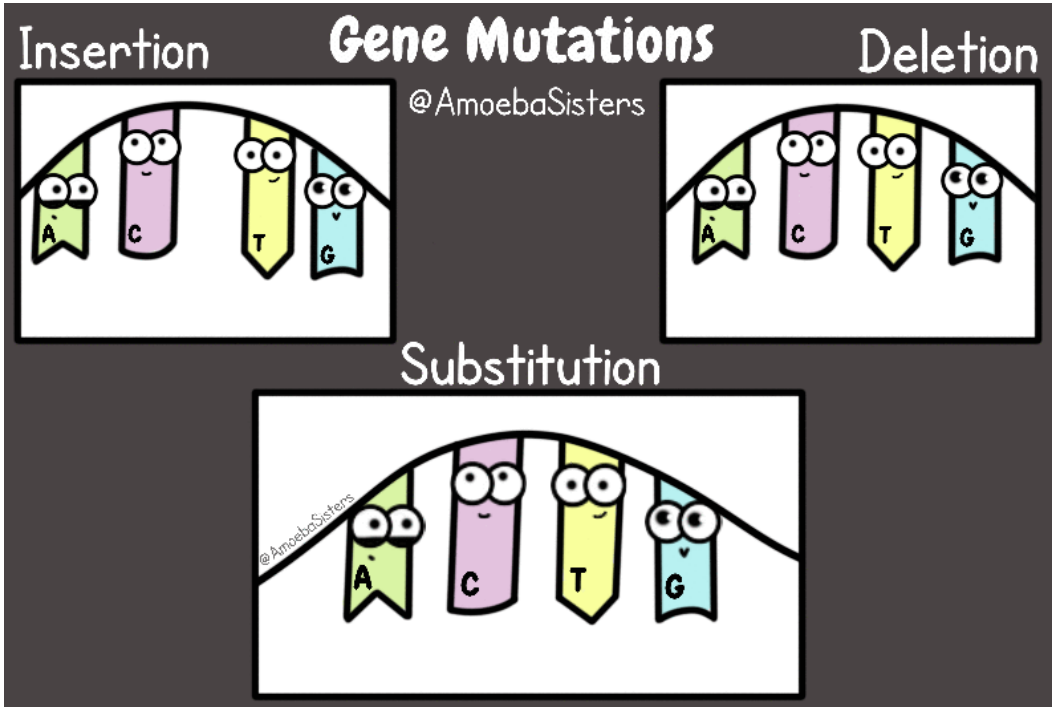
DNA coding strand:	ATG GGA ACT TAG	original
DNA template strand:	TAC CCT TGA ATC	
mRNA transcript:	AUG GGA ACU UAG	
amino acid sequence:	Met Gly Thr Stop	
DNA coding strand:	ATG GGG TAA CTT AG	frameshift insertion
DNA template strand:	TAC CCC ATT GAA TC	
mRNA transcript:	AUG GGG UAA CUU AG	
amino acid sequence:	Met Gly Stop	

Mutations

When one or more bases are *inserted* or *deleted* in DNA it shifts the "reading frame" of codons read during translation; hence: **frameshift mutation.**

One or two base frameshifts lead to an entirely different sequence of amino acids and therefore a different protein. This can be extremely detrimental to a cell.

Three base frameshifts are not usually as harmful given that the DNA code is read in triplets.



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gif credit: Amoeba Sisters

Effects of Mutations: Positive and Negative

- Many mutations are not repaired
- Effects of mutations depend on the nature of the mutation and the strategies available to the organism
- Mutations are permanent* and heritable
- Passed on to the offspring of organisms and new viruses and become a long-term part of the gene pool
- A small number of mutations contribute the success of the individual and the population
- Variant strains with alternate ways of expressing a trait can more readily adapt, survive, and reproduce

*sometimes a mutated gene will mutate back into its original sequence - this is called a **back mutation**

Imperfect Cell
(from Dragon Ball Z)

artist credit: Canis Minor Art

Micro is Magikal!