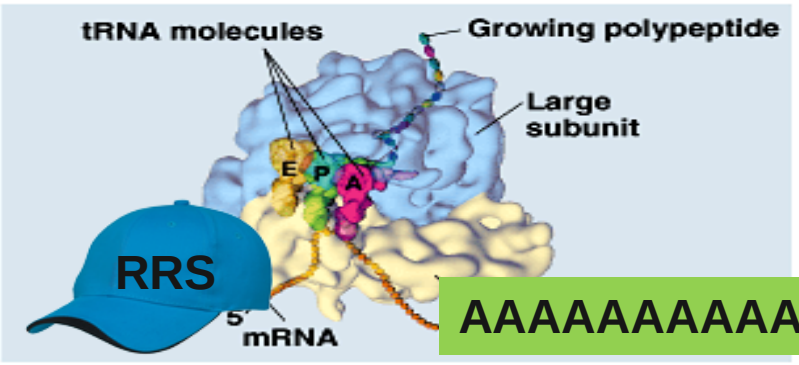
Part II: Translation

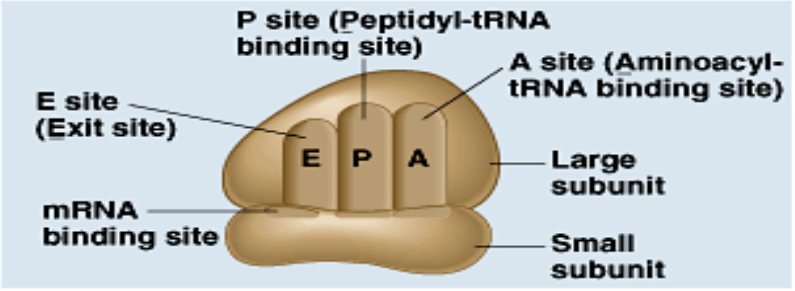
convert from mRNA language into **protein** language

Ribosomes

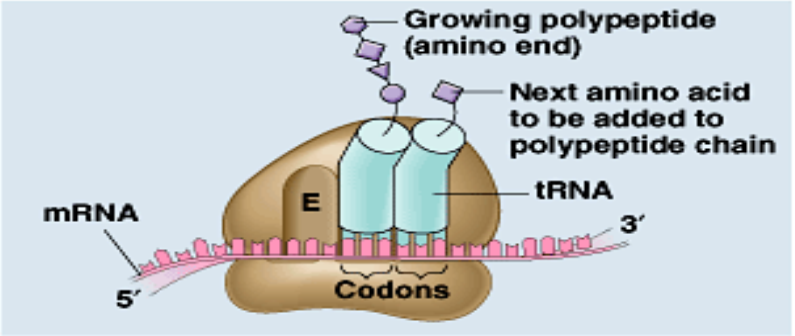
- First the mRNA binds to a ribosome in the cytoplasm or on the RER using its **RRS** in the CAP



(a) Computer model of functioning ribosome



(b) Schematic model showing binding sites



(c) Schematic model with mRNA and tRNA

How does mRNA code for proteins?

DNA TACGCACATTTACGTACGCGG

mRNA AUGCGUGUAAAUGCAUGCGCC

protein Met Arg Val Asn Ala Cys Ala

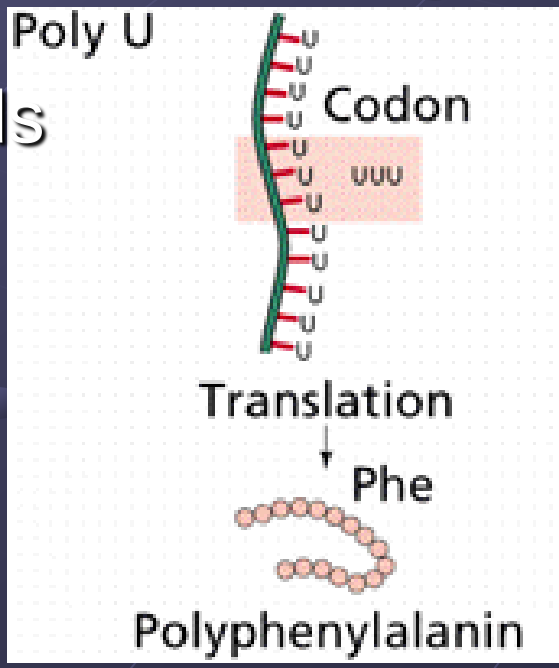
How can you code for 20 amino acids with only 4 nucleotide bases (A,U,G,C)?

1960 | 1968

Cracking the code

- Nirenberg & Matthaei
  - determined 1st codon–amino acid match
    - UUU coded for phenylalanine
  - created artificial poly(U) mRNA
  - added mRNA to test tube of ribosomes, tRNA & amino acids
    - mRNA synthesized single amino acid polypeptide chain

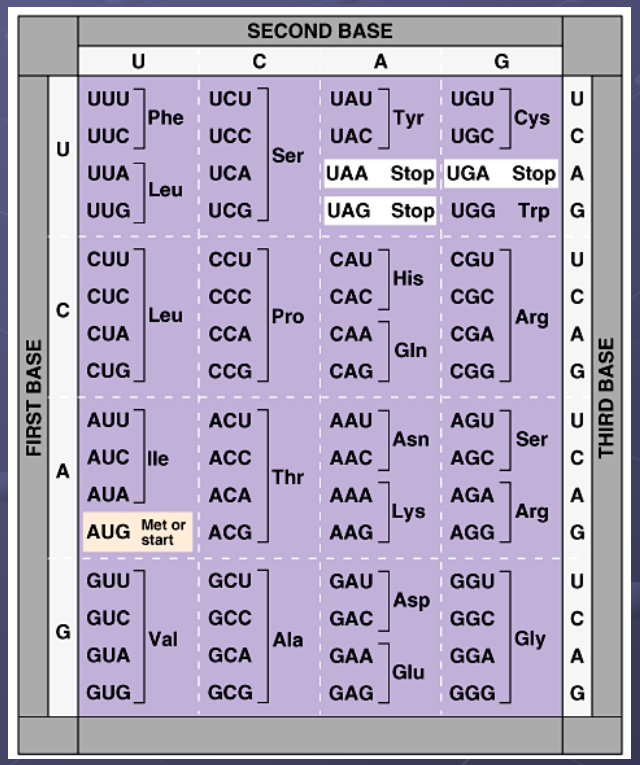
phe–phe–phe–phe–phe–phe



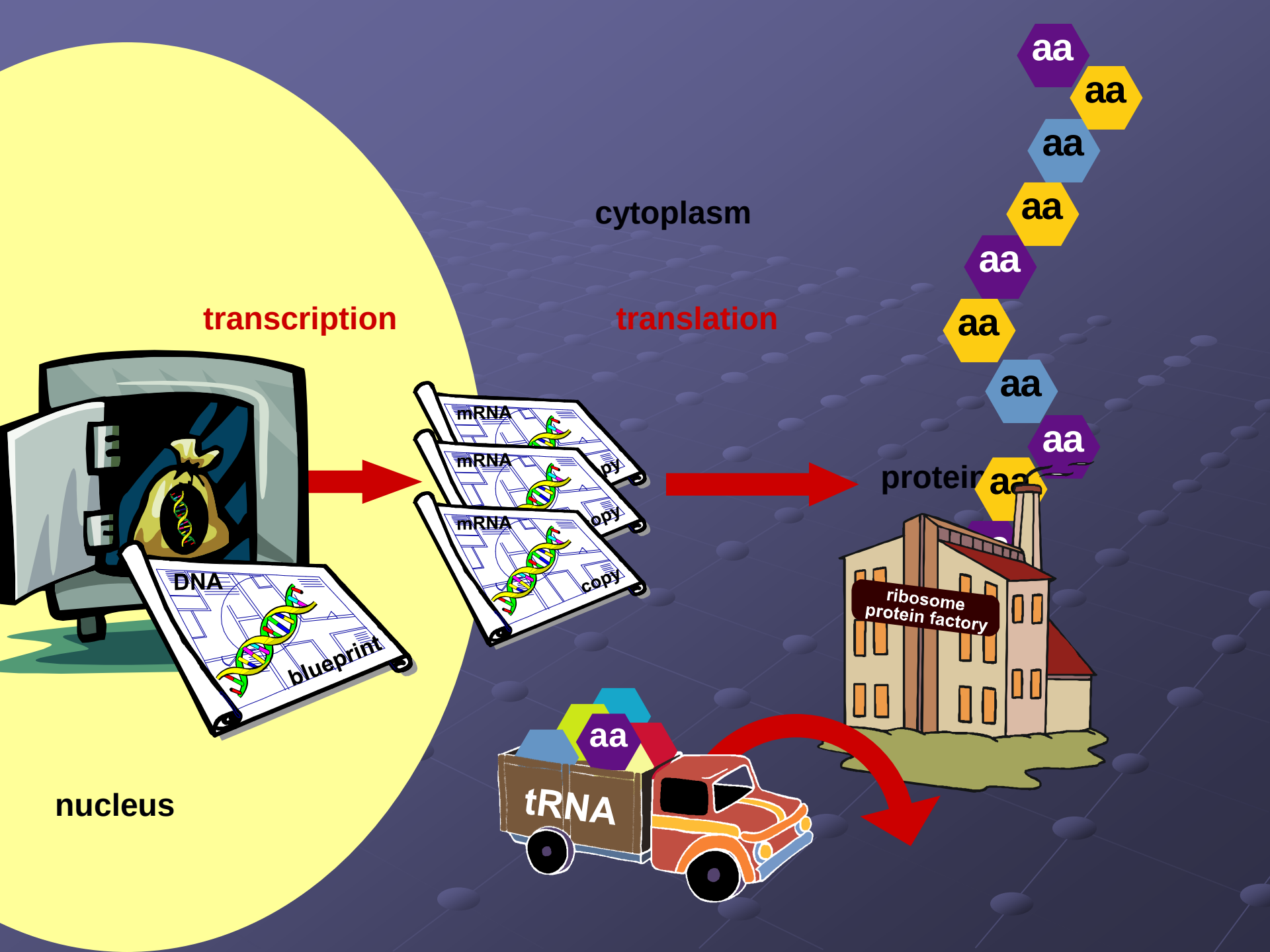
mRNA codes for proteins in triplets

DNA TACGCACATTTACGTACGCGG

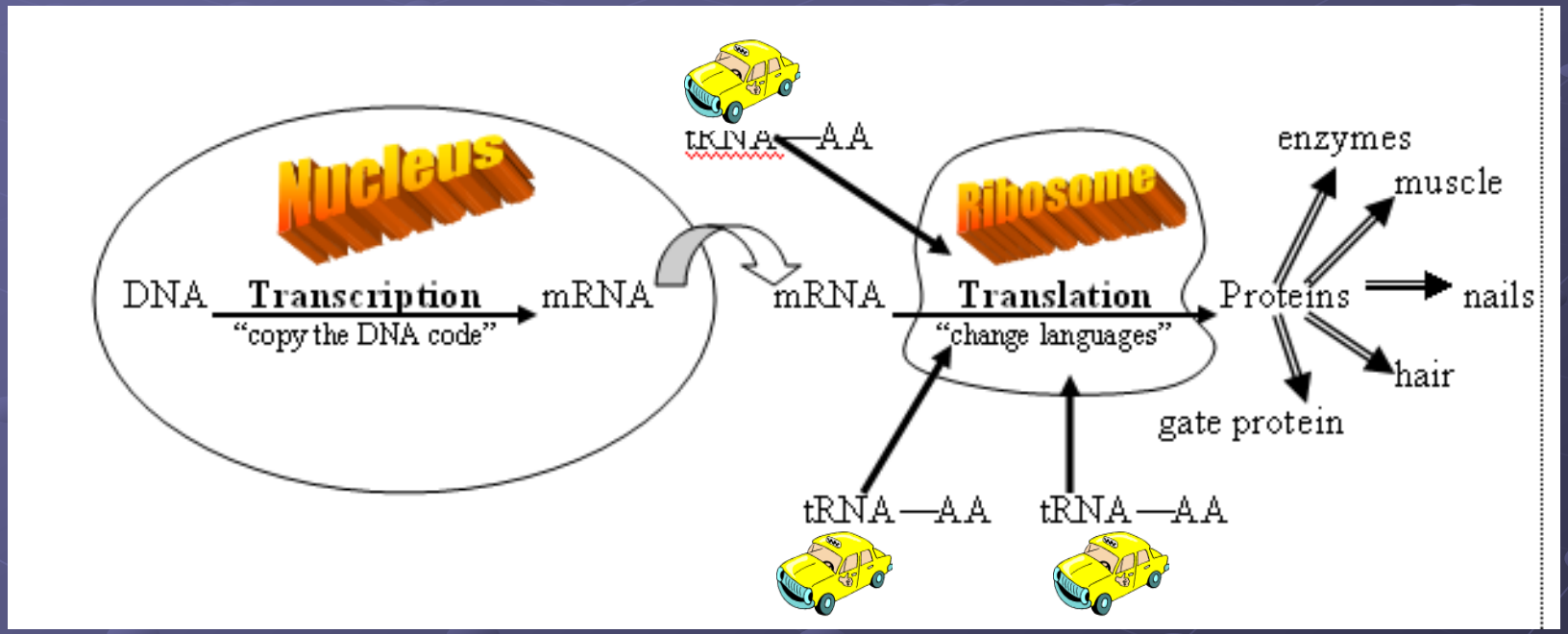
- The mRNA is read **3** letters at a time (**CODON**)
- Each CODON represents one specific **Amino Acid**
  - There are **64** possible 3 letter combinations BUT only **20** amino acids….
    - SO, some Codons code for more than one amino acid



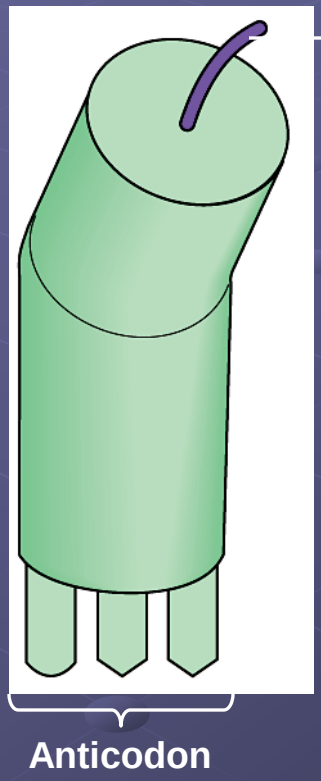
FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met or start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G


nucleus
transcription
DNA
blueprint
mRNA
mRNA
mRNA
copy
cytoplasm
translation
aa
aa
aa
aa
aa
aa
aa
aa
protein
ribosome
protein factory
aa
tRNA

- Once the mRNA reaches the __ribosome__, and the __CODONS__ are read,
- Transfer RNA (tRNA) "__Taxi__" service delivers the correct __Amino Acid__ to the ribosome



- Each tRNA molecule has a triplet anticodon on one end and an amino acid attachment site on the other



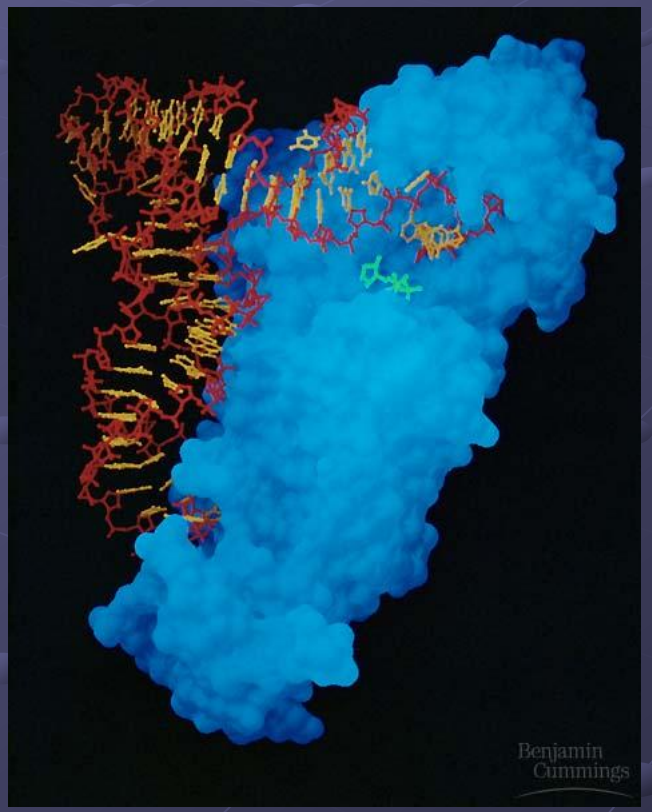
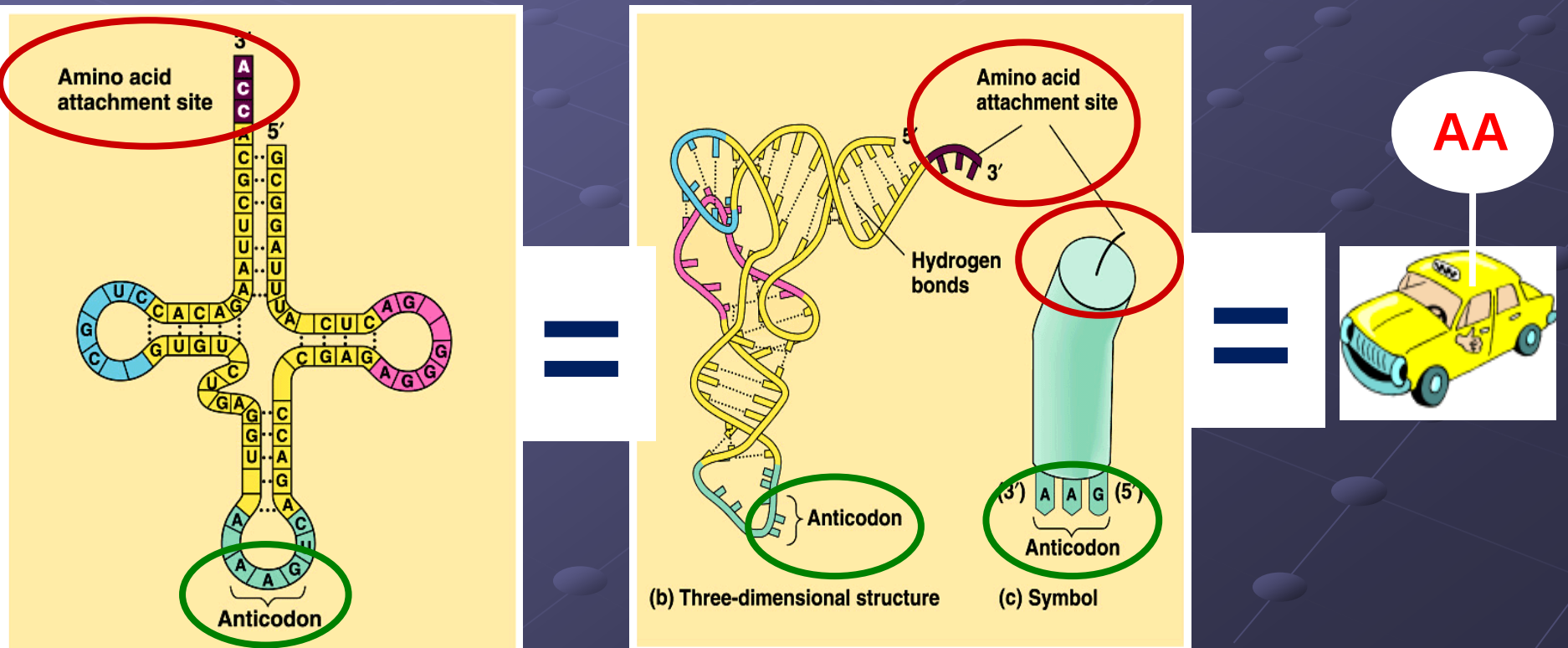


Figure 10.11B, C

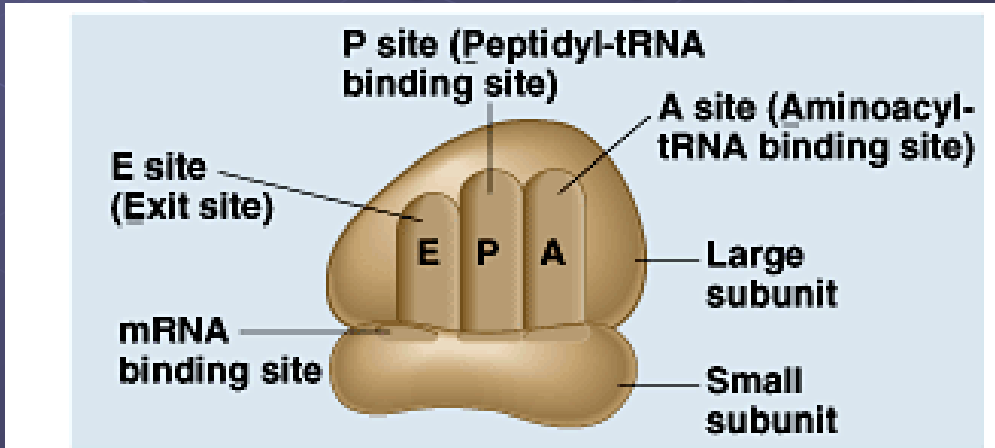
tRNA delivers the correct Amino Acid

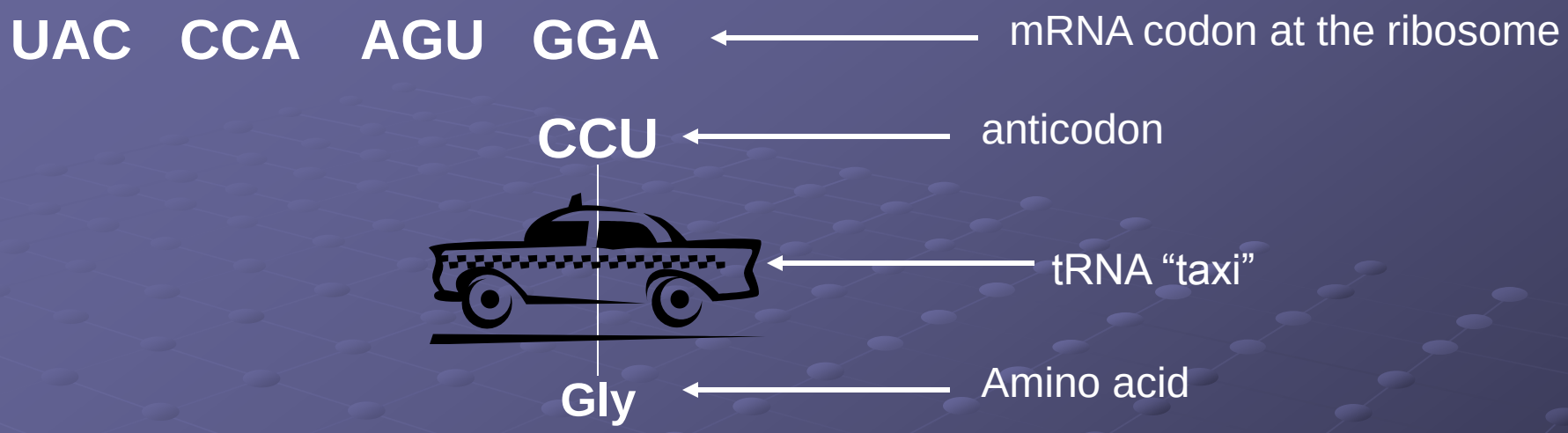
- "Clover leaf" structure
  - anticodon on "clover leaf" end
  - amino acid attached on 3' end



Ribosomes

- tRNA binds to the mRNA CODON with its matching 3-letter **ANTICODON**
- tRNA first Attaches to the ribosome at the **A** site (**A = Attach**)
- The ribosome **slides** down the mRNA to read the next codon
- This also causes the tRNA to slide from the A site to the **P** site (P = **Pass** the growing polypeptide)

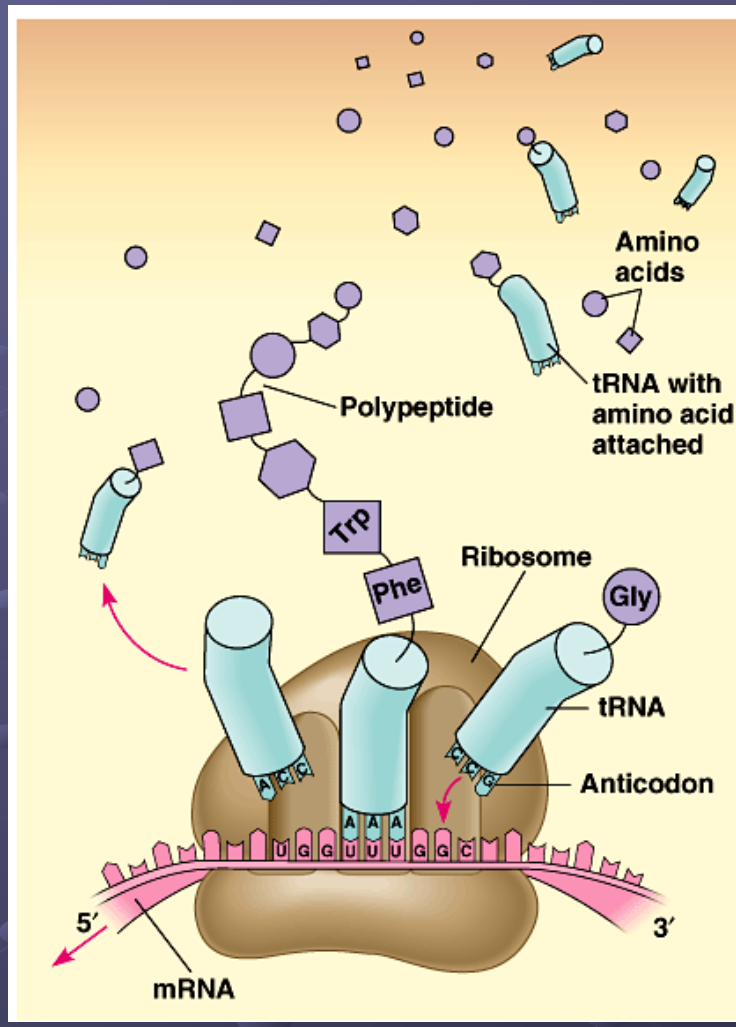


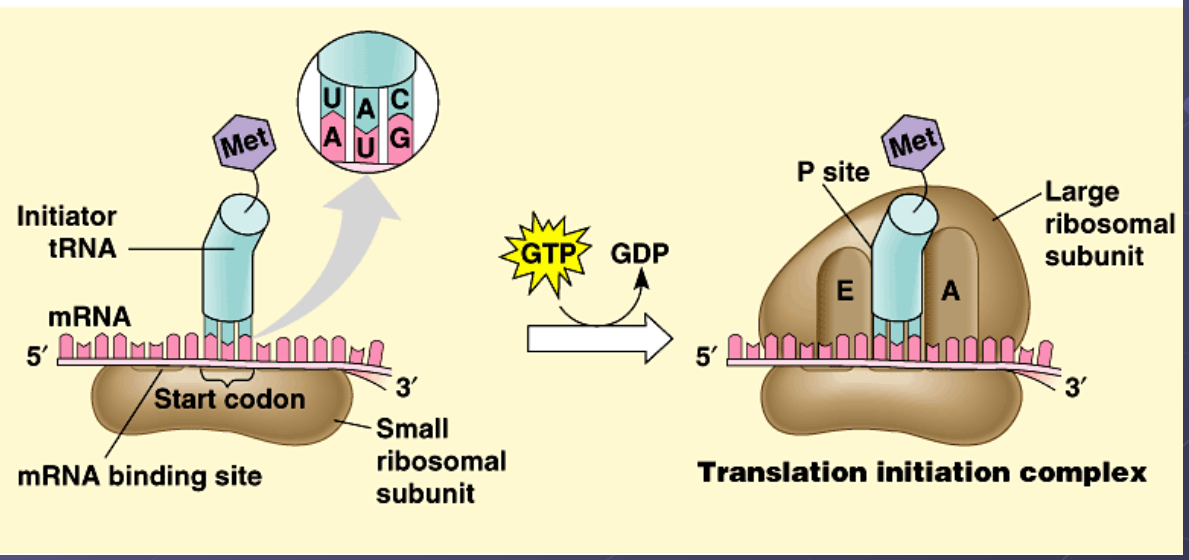


- tRNA releases its **AA** "passenger" which bonds to other AA to make a **polypeptide**
- the **empty** tRNA leaves the ribosome to pick up other **AA** passengers
- The protein is completed when a **STOP** codon is read

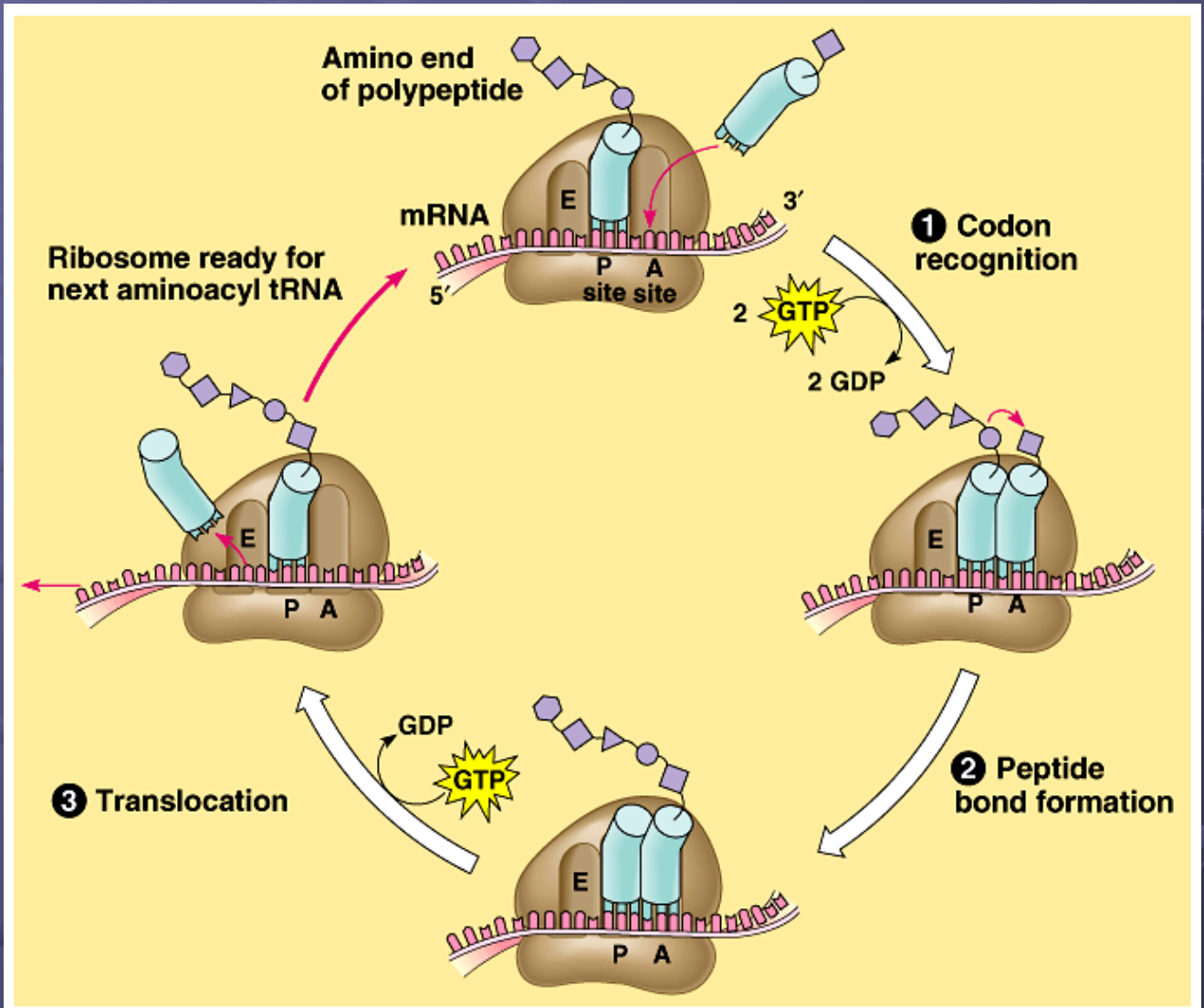
Building a polypeptide

- Initiation
  - brings together mRNA, ribosome subunits, proteins & initiator tRNA
- Elongation
- Termination

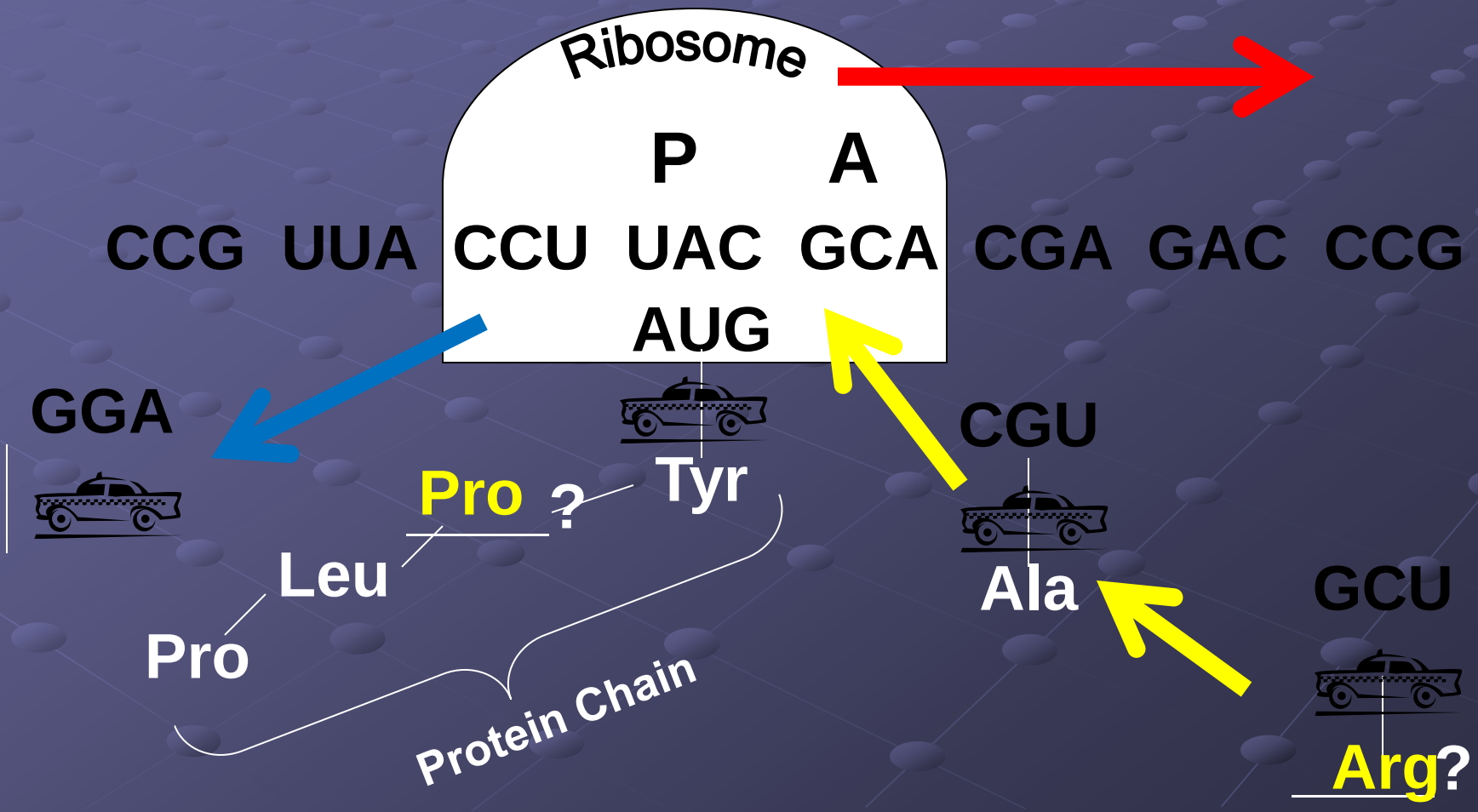




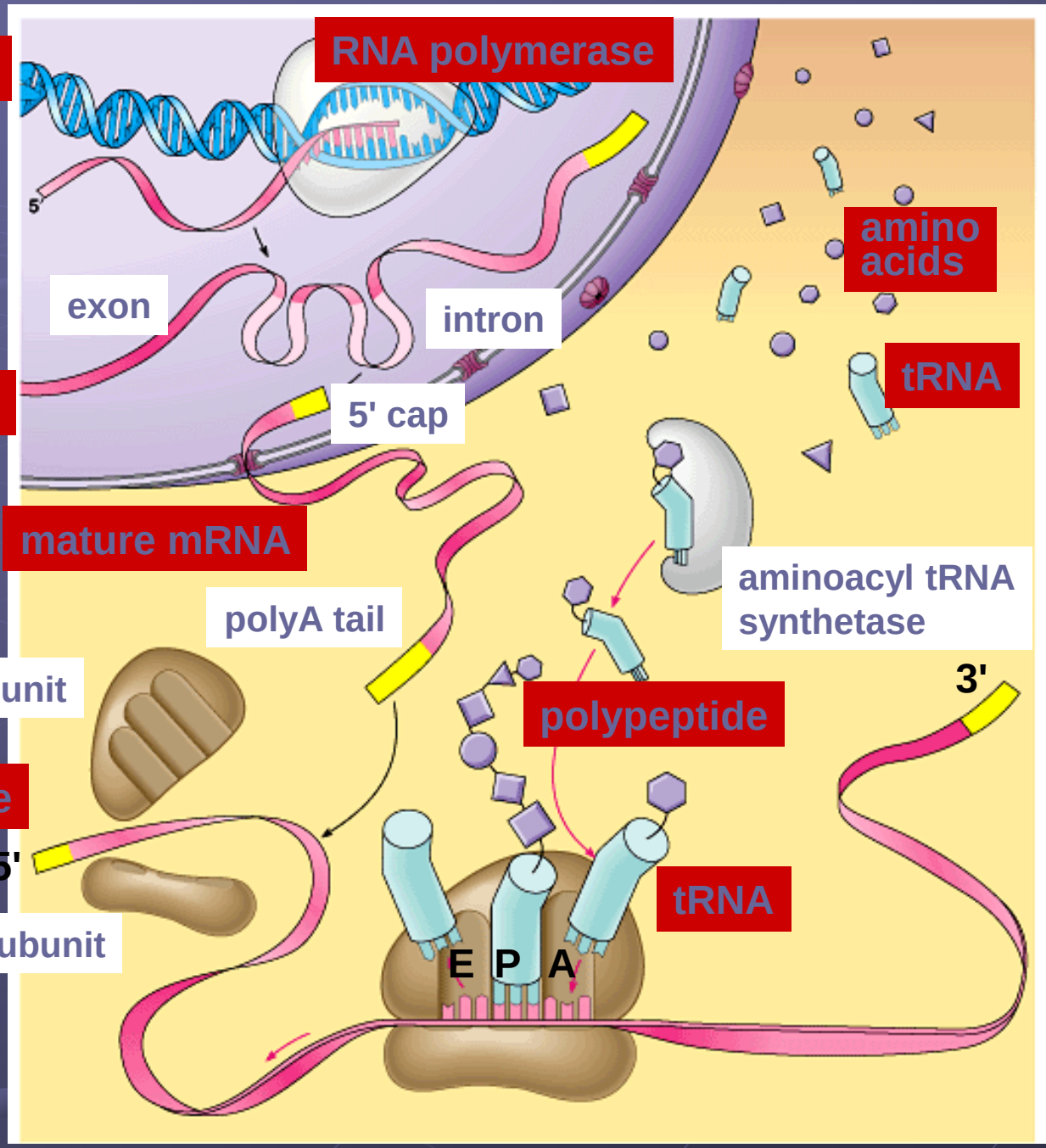
Elongation: growing a polypeptide



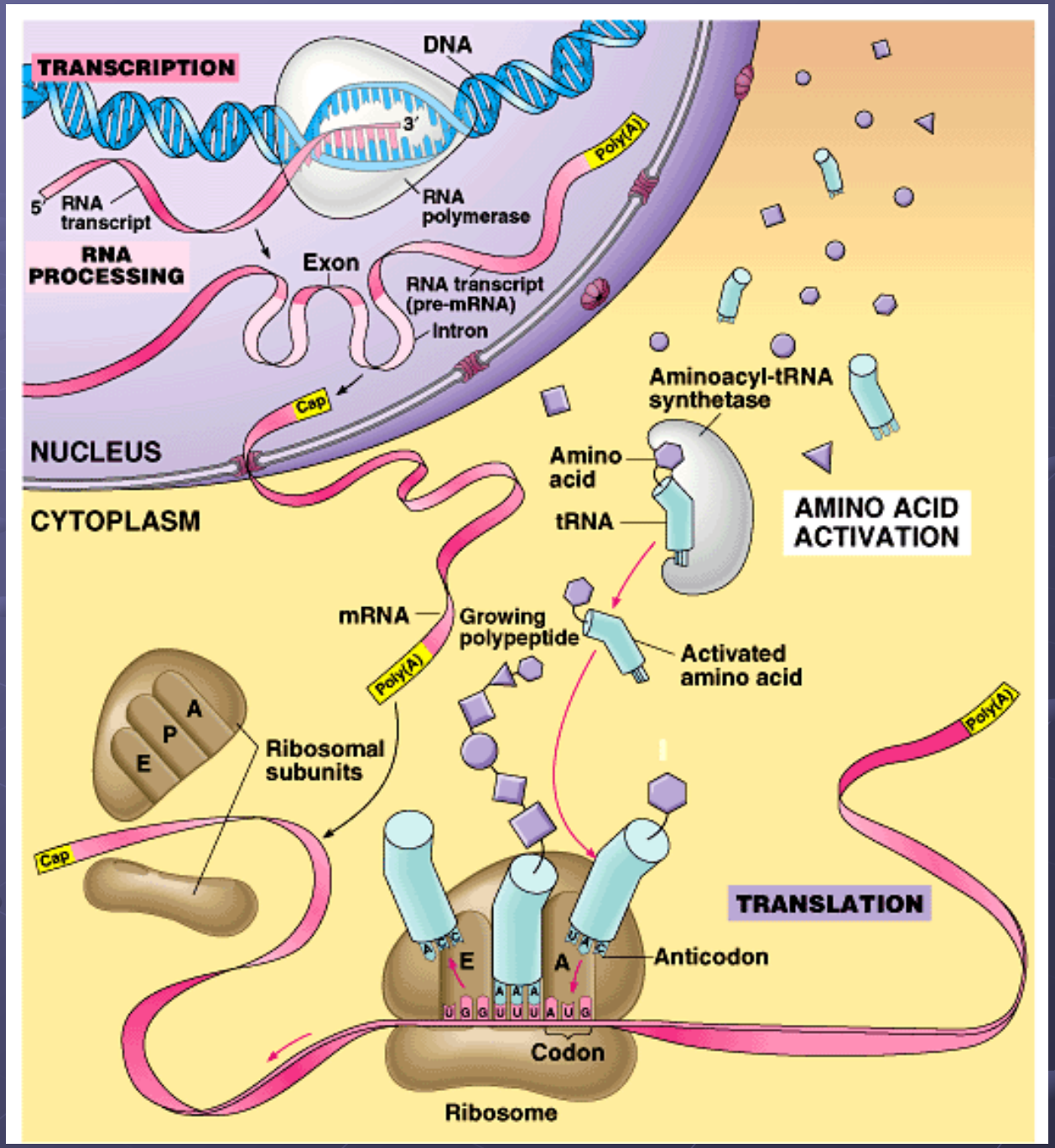
Translation



Can you tell the story?



Put it all together…



Mutation = changing the letter codes of a gene

A. Mutation **CAUSES**:

1. During DNA **Replication**:
   - Base-pairing mistakes can happen but most are **fixed**
2. Exposure to powerful **Chemicals**:
   - **Cigarette** smoke, smokeless tobacco, exhaust from burning petroleum fuels, pesticides, herbicides, alcohol, sawdust from CCA lumber, paints, mineral spirits & oils, asbestos, etc.
3. Exposure to powerful **Radiation**:
   - **Gamma rays** (nuclear fuel & bombs)
   - **X-rays** (at hospitals & dental offices)
   - **UV rays** (from sunlight and tanning beds)

B. Mutation Types

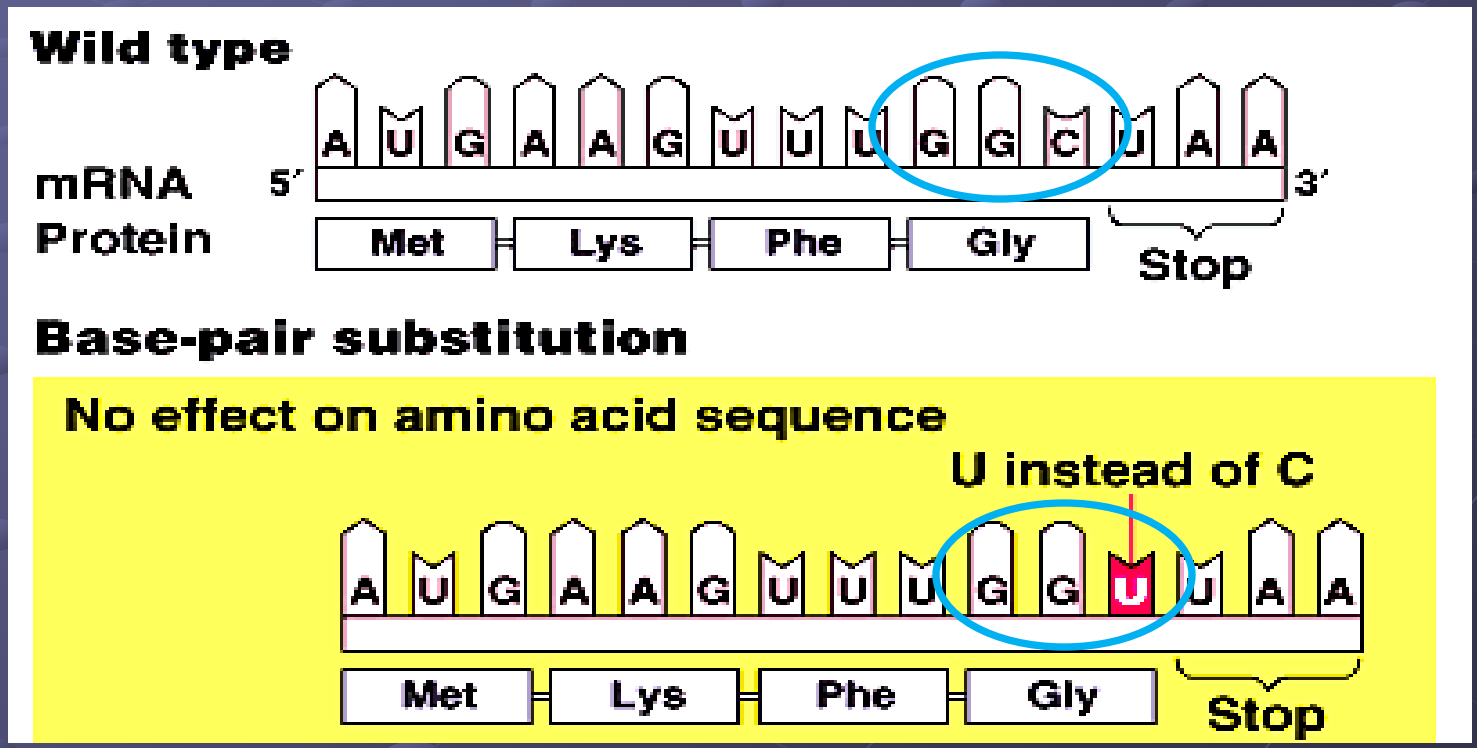
			Original gene		**mutated** gene
1.	Addition	= add 1+ letters	TAGACAT	→	TAGACCAT
2.	Deletion	= lose 1+ letters	TAGACAT	→	TGACAT
3.	Substitution	= switch 1+ letters	TAGACAT	→	TAGAGAT

C. Mutation Effects: Was the protein produced any different **shape** than the original?

1. **NO** effect = protein remains the same → **same** shape
2. **Small** effect = protein has 1+ different AA → **Small** shape change
3. **BIG** effect = protein has many different AA → **Big** shape change

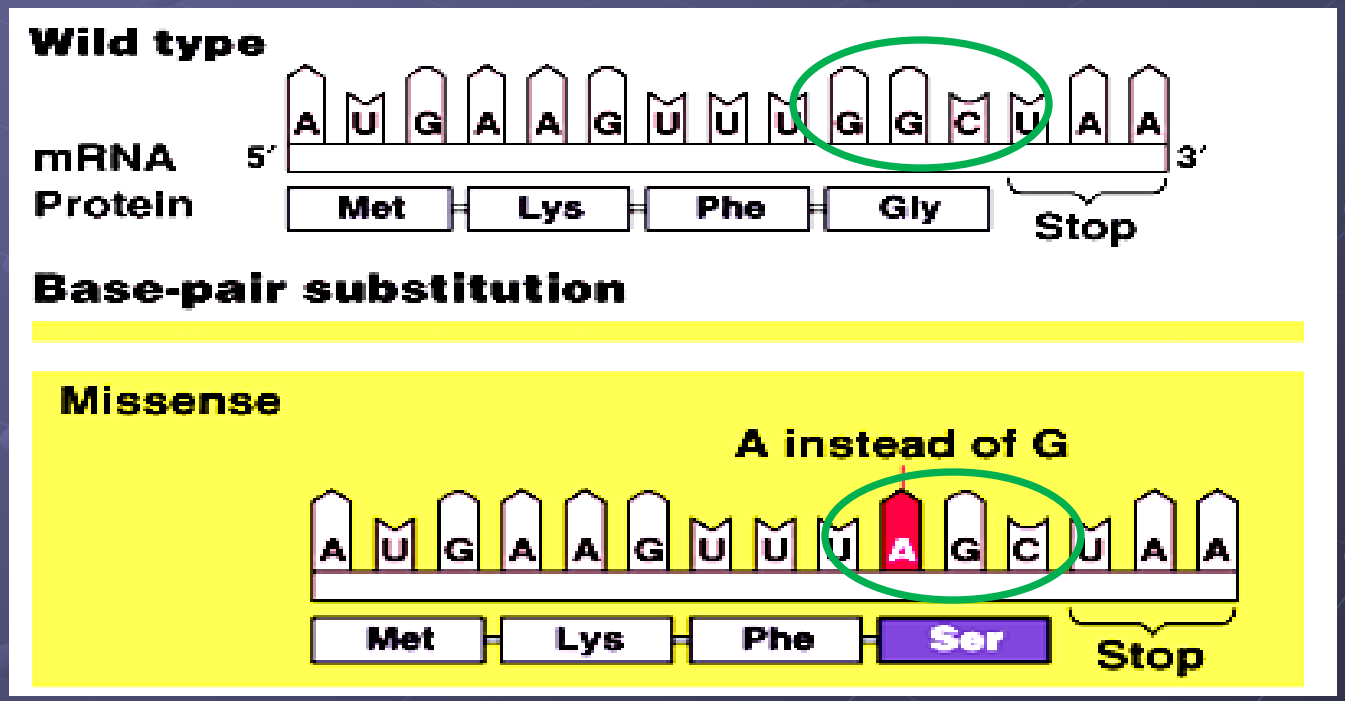
Mutation Effects: None or Small or BIG?

1) **Silent** mutation = changes a CODON but still specifies the **SAME** AA = **NO** Effect



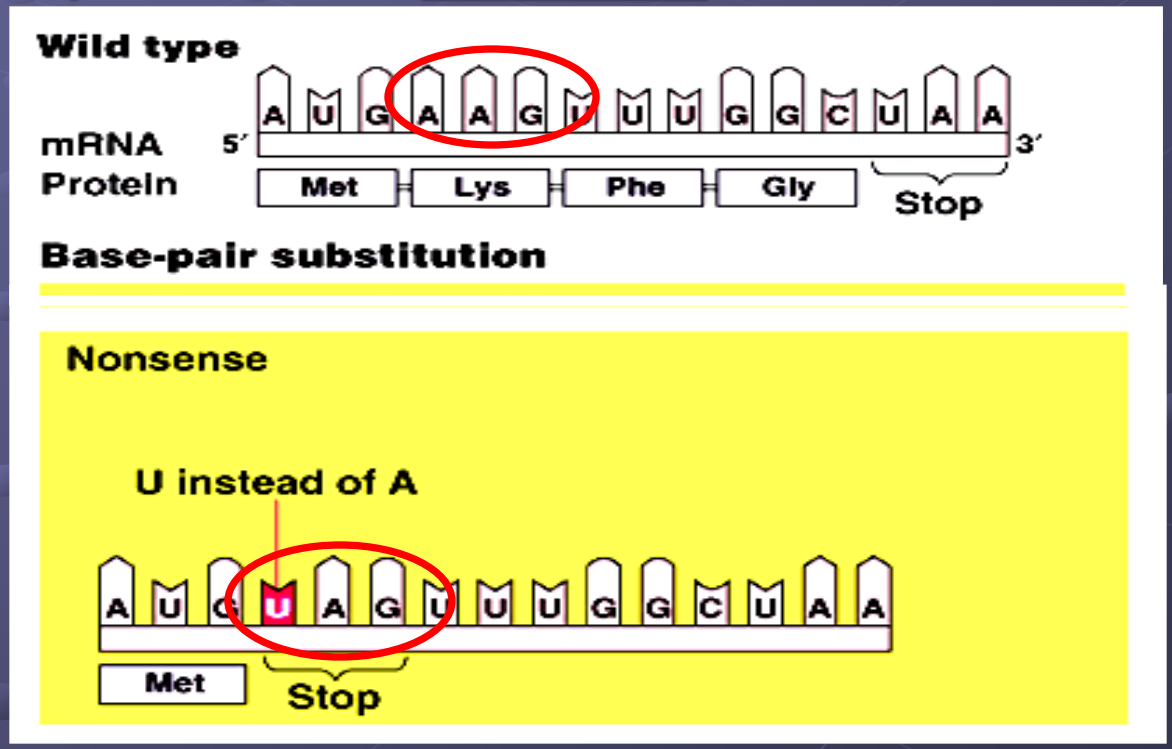
Mutation Effects: None or Small or BIG?

2) **Missense** mutation = changes a CODON that will specify a **DIFFERENT** AA = **small** effect



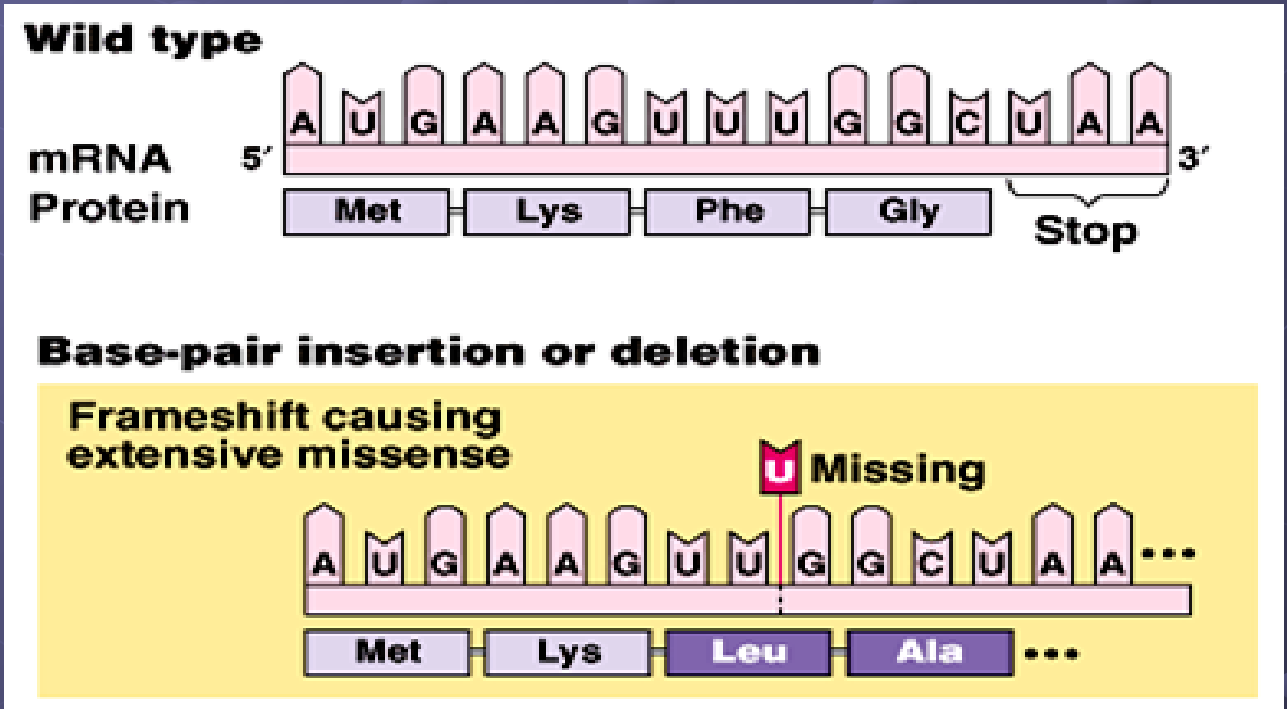
Mutation Effects: None or Small or BIG?

3) **Nonsense** mutation = changes a CODON to specify a **STOP** signal in the middle of the protein = **BIG** effect



Mutation Effects: None or Small or BIG?

4) **Frameshift** mutation = 1+ bases add or lost causes the triplet reading frame to be **SHIFTED** over = **BIG** effect



Mutation Conclusions:

- Any protein **different** than the original probably will NOT fold into the same 3-D **SHAPE** = NOT FUNCTION = cause a **health** problem

- Most mutations have a **Negative (-)** effect that lowers an organism's chance for survival

  Ex.

- Some mutations have a **Positive (+)** effect for an organism in a certain environment that helps them better survive the challenges of life

  Ex.

- Accumulating DNA mutations often lead to diseases like **Cancer**

- Only DNA mutations in **eggs** and **sperm** cells can be inherited
  - These **inherited** mutations often result in a variety of genetic **diseases**

Mutation Conclusions:

- Some viruses mutate **quickly** because mistakes during **replication** of their genetic material are NOT fixed by proofreading repair enzymes
- This leads to new **strains** of disease-causing viruses that sometimes emerge to cause major health **epidemics**.
- This happens because people have little immunity to the viruses' newly-shaped **proteins**