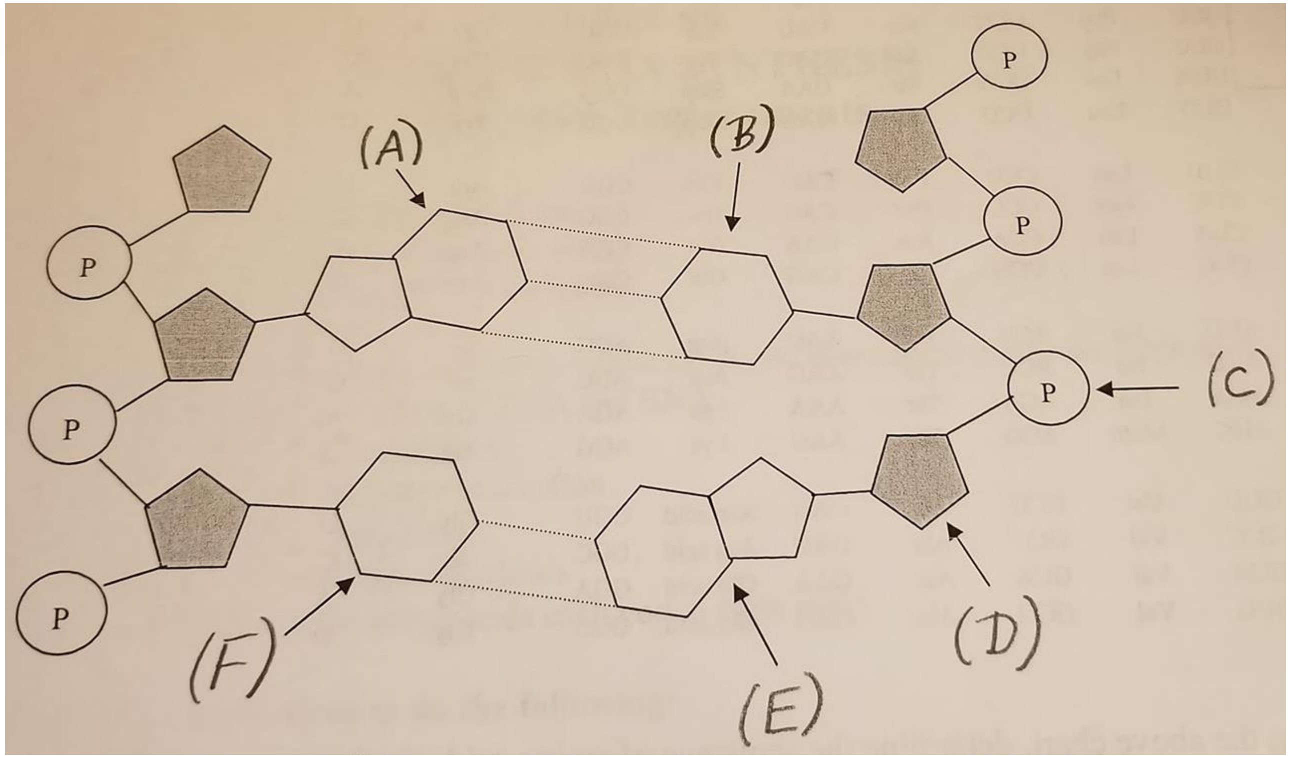
Thursday 11/29

Reminders

- Next week
  - Monday December 3rd – Unit 5 Vocabulary Quiz
  - Monday December 3rd *AFTER SCHOOL* Unit 4 Makeups (Quiz, Exam, Practical)
  - Tuesday December 4th – Unit 5 Exam
  - Wednesday December 5th – Prefix/Suffix Quiz #6
  - Thursday December 6th – Unit 5 Practical Test

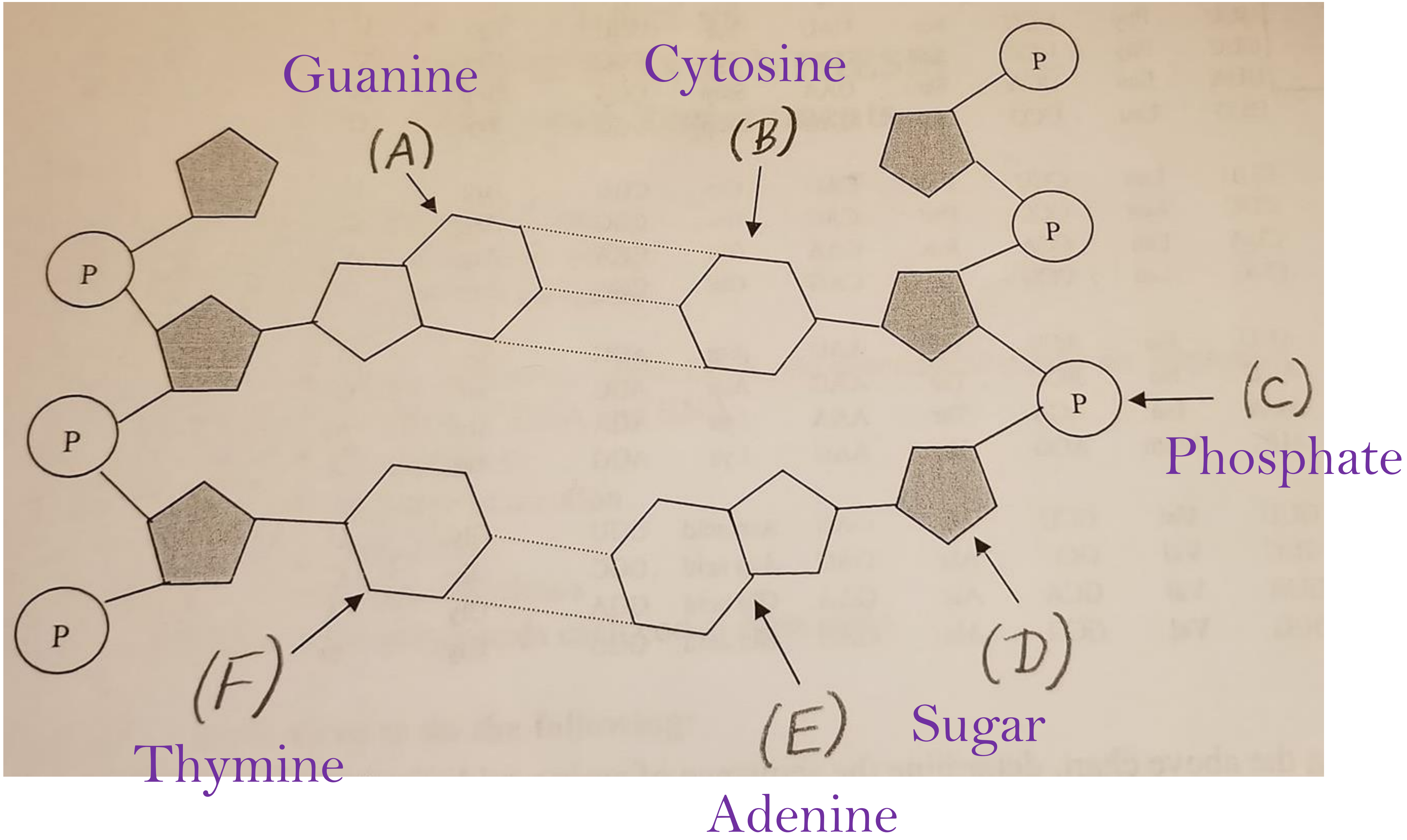
P.O.D.

- What are the 4 criteria that Watson & Crick knew they had to work with when developing their model of the structure of DNA?
- Identify (A), (B), (C), (D), (E), & (F)



The Four Criteria

1) The molecule must be able to store A LOT of information
2) The molecule must be able to copy itself with great precision
3) The molecule must be able to make mistakes when being copied
4) The molecule must be readable by cells

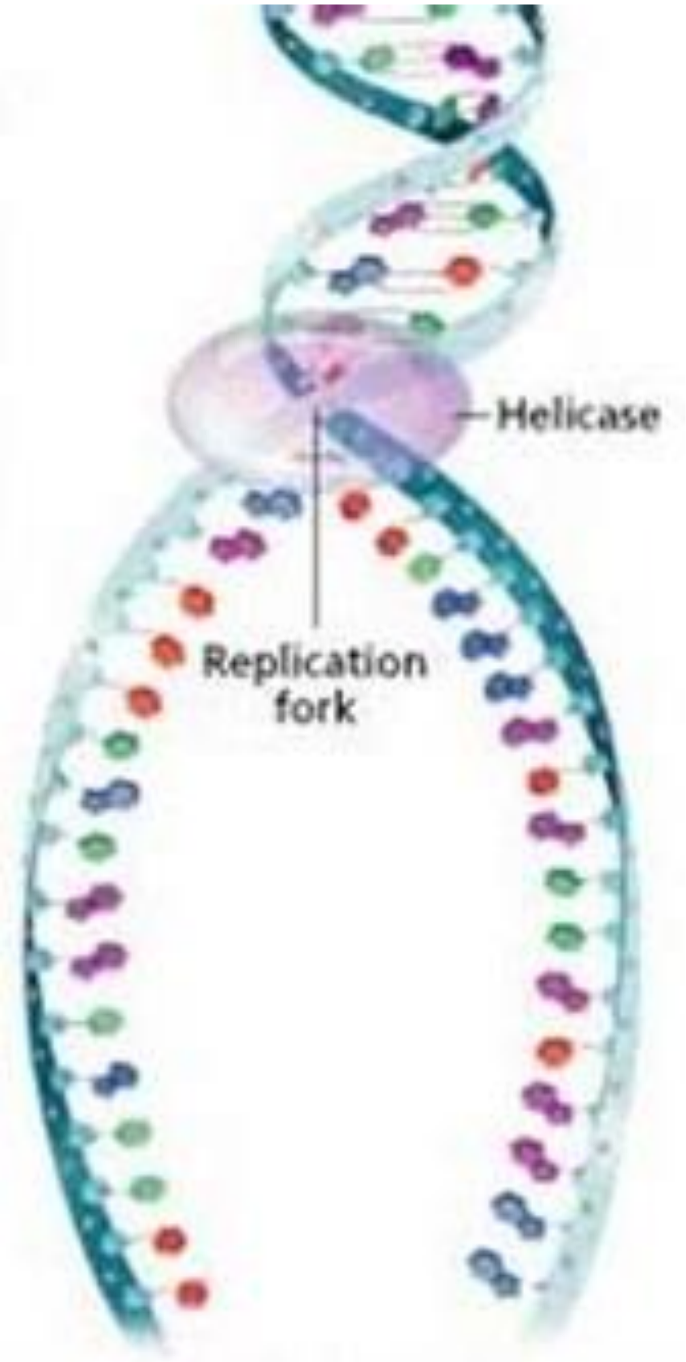

Guanine
(A)
Cytosine
(B)
P
P
P
P
P
P
P
(C)
Phosphate
(D)
Sugar
(E)
Adenine
(F)
Thymine

DNA Replication

- Remember that DNA is a double helix where one side of the “ladder” is the complement of the other side
  - This is what makes precise replication possible

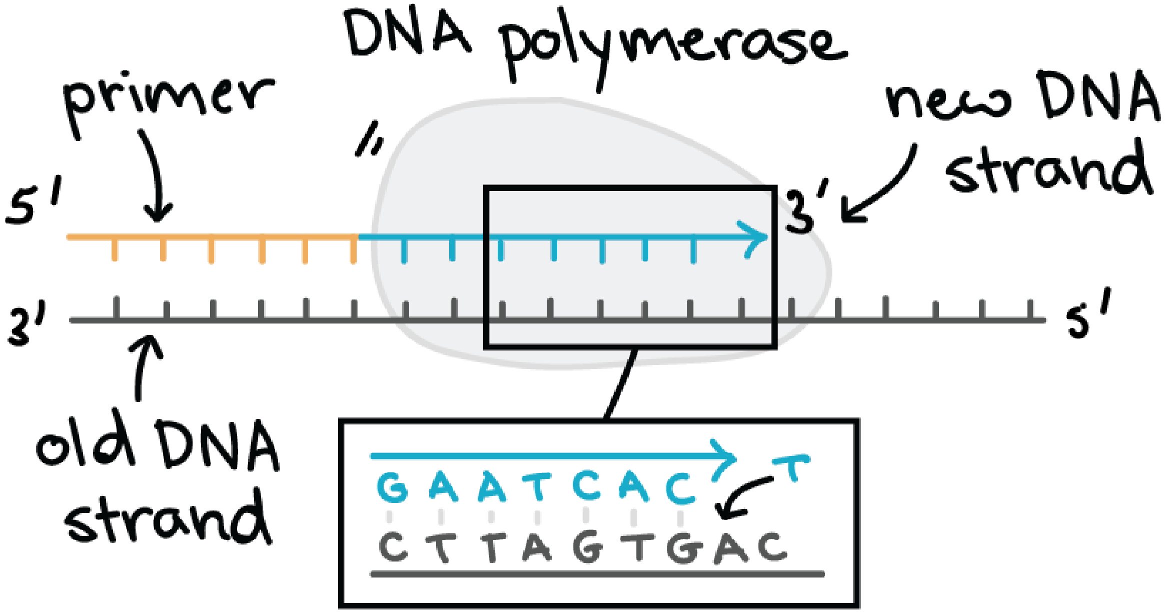
DNA Replication

DNA helicase breaks the hydrogen bonds between base pairs, which "unwinds" and "unzips" the DNA



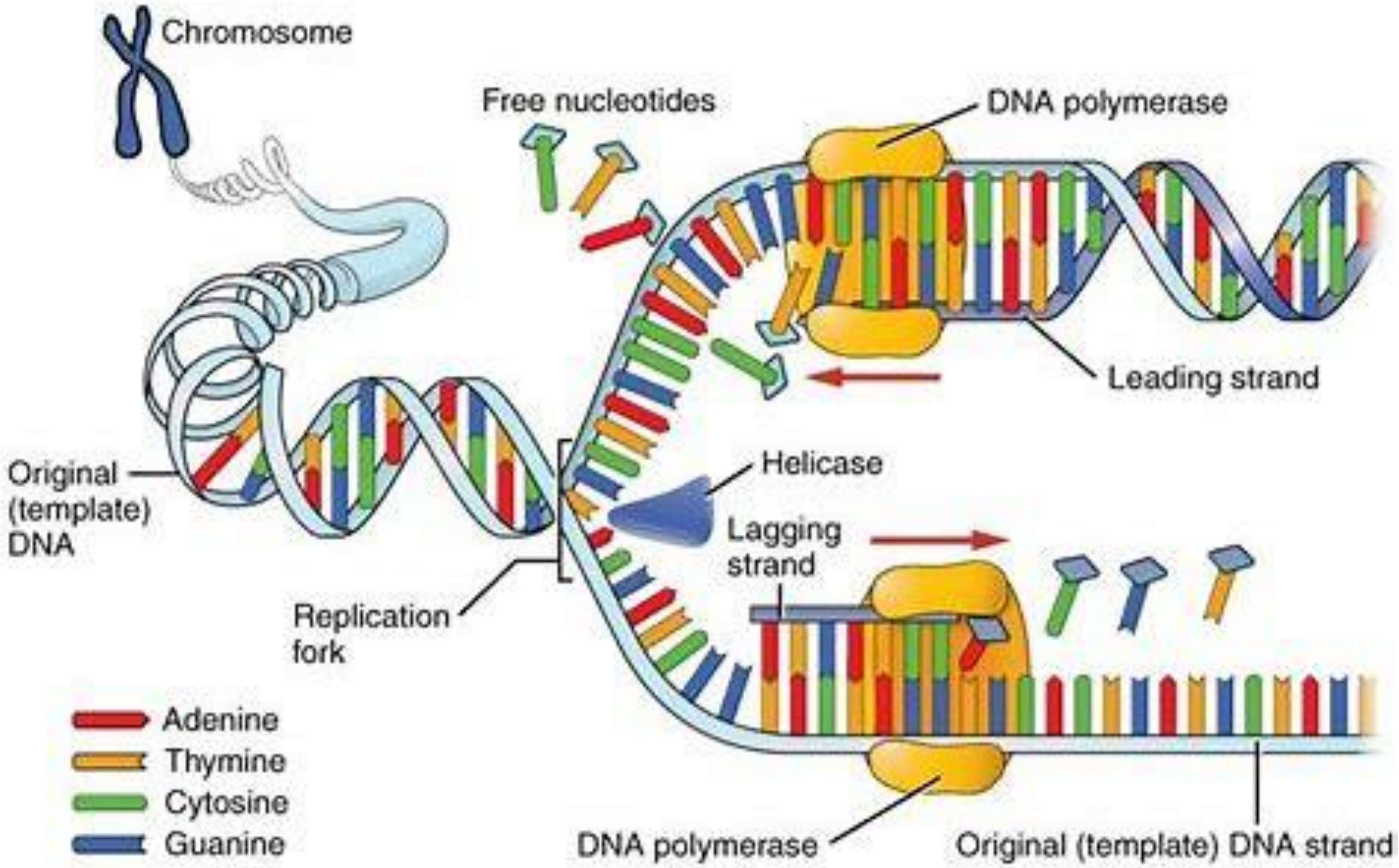
DNA Replication

- Each strand in the double helix acts as a template for the synthesis of a new and complementary strand



DNA Replication

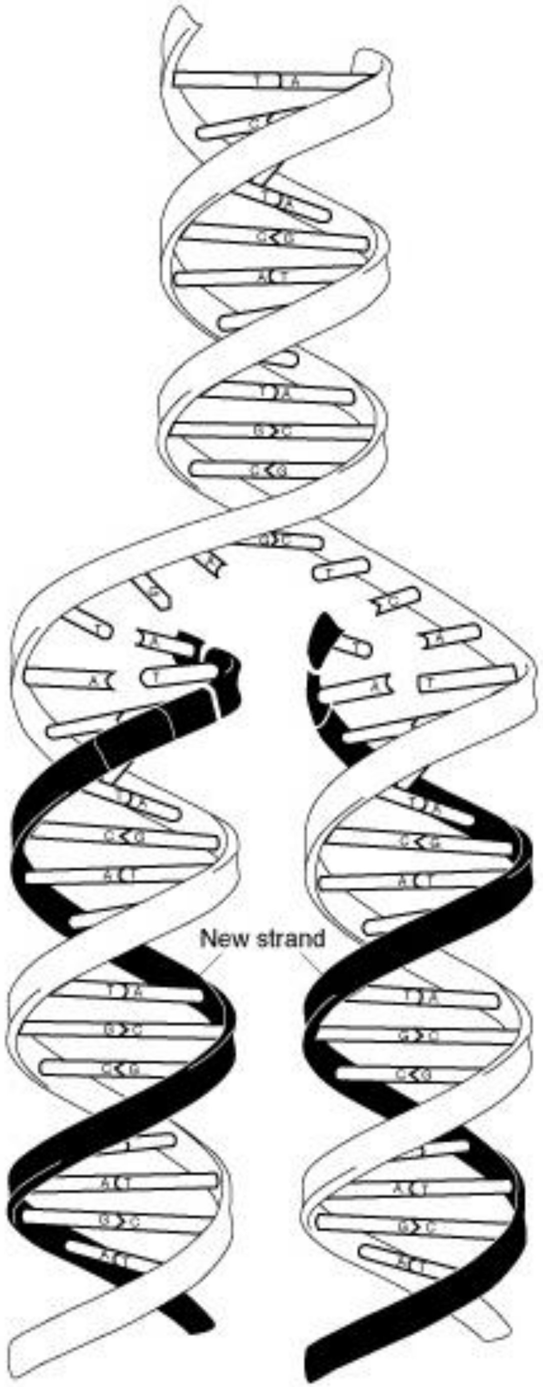
DNA polymerase adds complementary nucleotides one by one to both templates



DNA Replication

- This results in two “daughter” identical strands of DNA
  - Each with one new strand and one old strand
    - Semiconservative

DNA Replication



Mistakes in Copying

- Sometimes, a mistake is made when adding complementary base pairs and the wrong bases are paired together
  - That means that the mistake has the potential to change many things

Mistakes in Copying

- Genes code for certain proteins and traits and can turn other genes off or on
  - Mistakes can turn out to be good and they can even lead to no actual change, but they can also be deadly

Mistakes in Copying

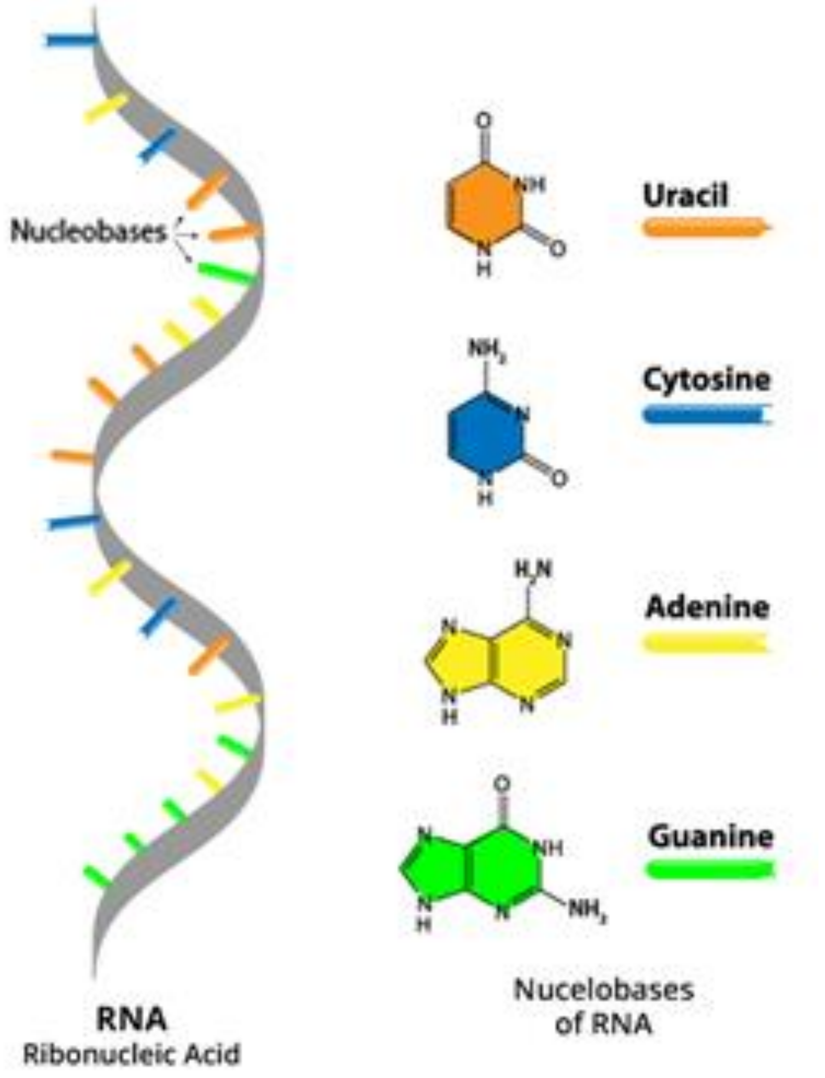
- About 1 in 10^5 base pairs can result in an incorrect pairing
  - DNA polymerase proofreads as it adds nucleotides
    - It can remove the vast majority of the mistakes that are made

Mistakes in Copying

- What a mistake is good, neutral, or bad depends on how the DNA is read by the cell
  - This is the next part we will talk about in a bit

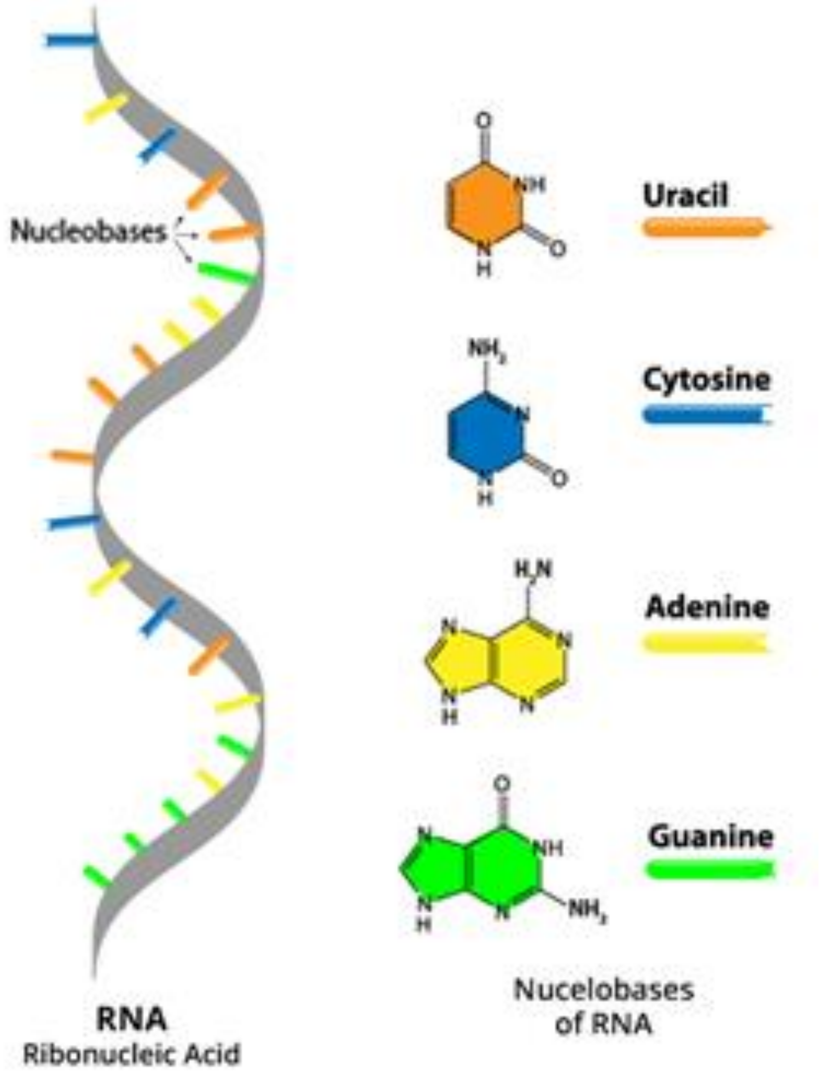
RNA – another nucleic acid

- Ribonucleic acid
  - Very similar to DNA but…
    - Has **ribose** instead of deoxyribose
    - **Single-stranded** instead of double stranded
    - **Uracil** (pyrimidine, 1 ring of carbon, 2 hydrogen bonds) instead of thymine



RNA – another nucleic acid

- RNA is the way that information is sent from the nucleus where DNA is stored to ribosomes where proteins are synthesized



Three types of RNA

- mRNA
  - messenger RNA: the RNA molecule transcribed from the DNA template
- tRNA
  - transfer RNA: RNA molecules that brings and binds amino acids to the ribosome and mRNA
- rRNA
  - ribosomal RNA: make up the ribosome (ribosomes are made out of RNA!)

Reading RNA

How many 3-letter 'words' can you make with the following 4 letters (they don't have to make sense)?

A

U

C

G

(you can use letters more than once)

A	U	C	G
AAA	UUU	CCC	GGG
AUC	UUA	CGC	GCG
AUG	UUC	CUA	GCU
AUA	UUG	CAU	GCA
ACG	UAU	CAC	CUA
ACA	UCU	CAG	GUC
AUA	UGU	CUA	GAG
etc.	etc.	etc.	etc.

P.O.D

A	T	C	G
- AAA	- TTT	- CCC	- GGG
- ATC	- TTA	- CGC	- GCG
- ACG	- TAT	- CAC	- GTA
- ACA	- TCT	- CAG	- GTC
- ATA	- TGT	- CTA	- GAG
- etc.	- etc.	- etc.	- etc.

AND EVEN MORE!

A math question….

- There are 4 letters and you want to make 3-letter words
- You may use letters multiple times
- To figure out how many possibilities there are….
  - Write out placeholders for how many letters you want in your word

______ ______ ______

A math question….

- There are 4 letters and you want to make 3-letter words
- You may use letters multiple times
- To figure out how many possibilities there are….
  - Write out placeholders for how many letters you want in your word
  - Then write the number of letters that could be used in that spot

4 4 4
___ ___ ___

A math question….

- There are 4 letters and you want to make 3-letter words
- You may use letters multiple times
- To figure out how many possibilities there are….
  - Write out placeholders for how many letters you want in your word
  - Then write the number of letters that could be used in that spot
  - Then, multiply those numbers together

4 x 4 x 4

A math question….

- There are 4 letters and you want to make 3-letter words
- You may use letters multiple times
- To figure out how many possibilities there are….
  - Write out placeholders for how many letters you want in your word
  - Then write the number of letters that could be used in that spot
  - Then, multiply those numbers together

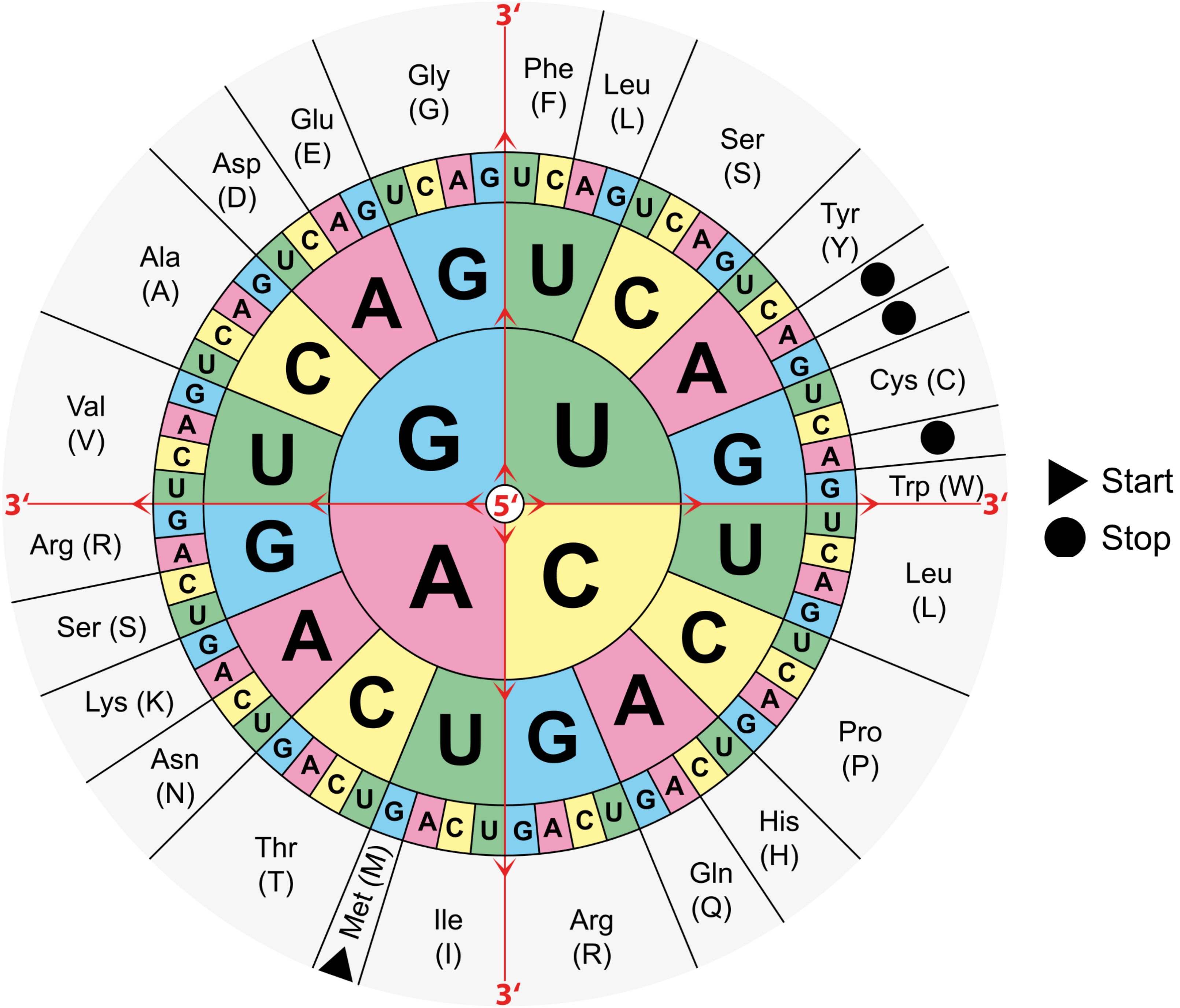
4 x 4 x 4 = 64

Reading DNA

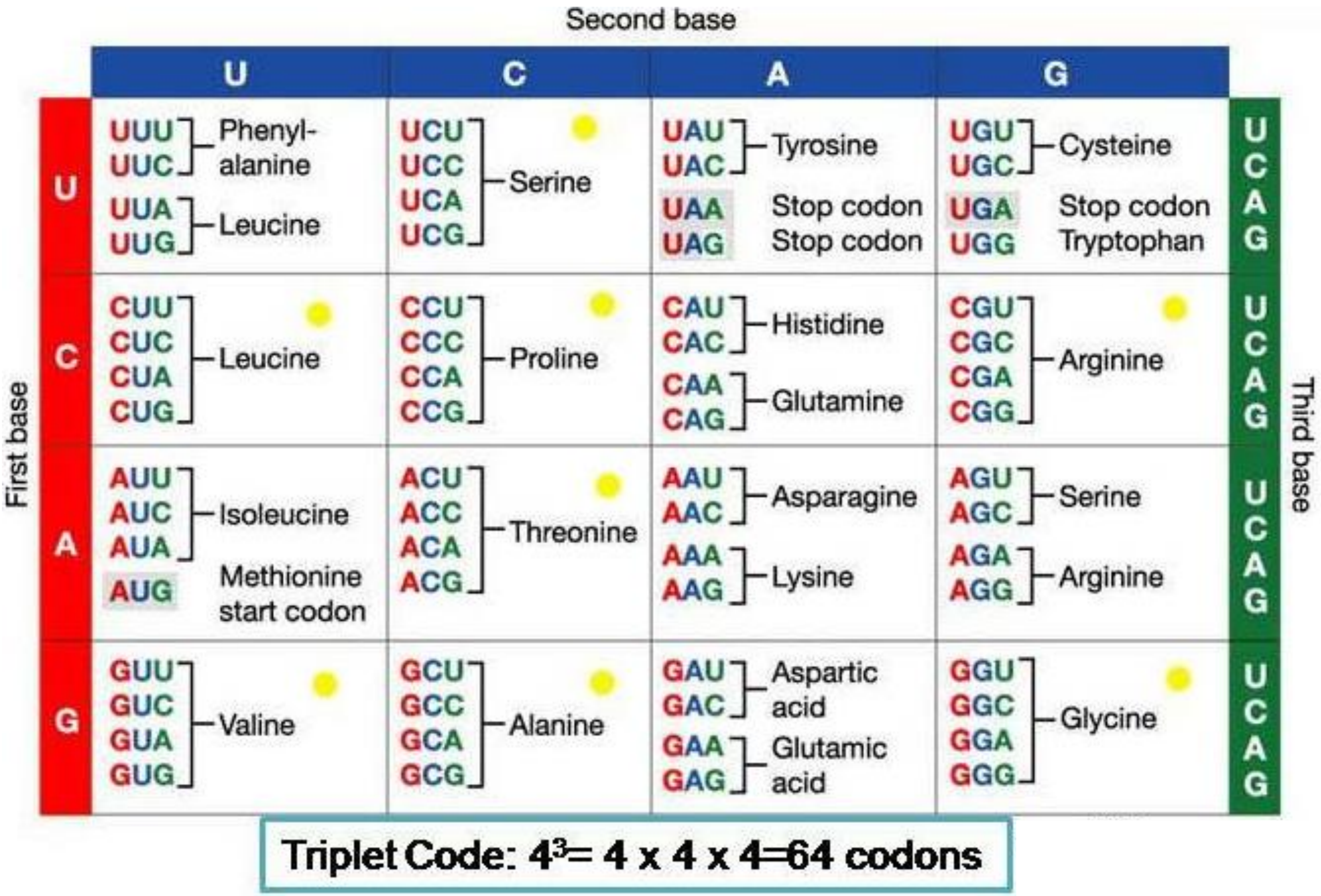
- Cells read DNA in groups of 3 base pairs at a time
  - Each set of 3 base pairs is called a codon
    - Codons code for amino acids
      - One amino acid can be coded for by multiple codons
        - … but each single codon will always code for the same amino acid

First base \ Second base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons



3'
5'
3'
3'
3'
Gly (G)
Phe (F)
Leu (L)
Ser (S)
Tyr (Y)
Cys (C)
Trp (W)
Leu (L)
Pro (P)
His (H)
Gln (Q)
Arg (R)
Ile (I)
Met (M)
Thr (T)
Asn (N)
Lys (K)
Ser (S)
Arg (R)
Val (V)
Ala (A)
Asp (D)
Glu (E)
Start
Stop



mRNA message transcribed from DNA:

UUUUACAGGGCCGUAGAAUGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome reads the mRNA message:

UUU | UAC | AGG | GCC | GUA | GAA | UGA

Second base

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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

Ribosome reads the mRNA message:

Phy | UAC | AGG | GCC | GUA | GAA | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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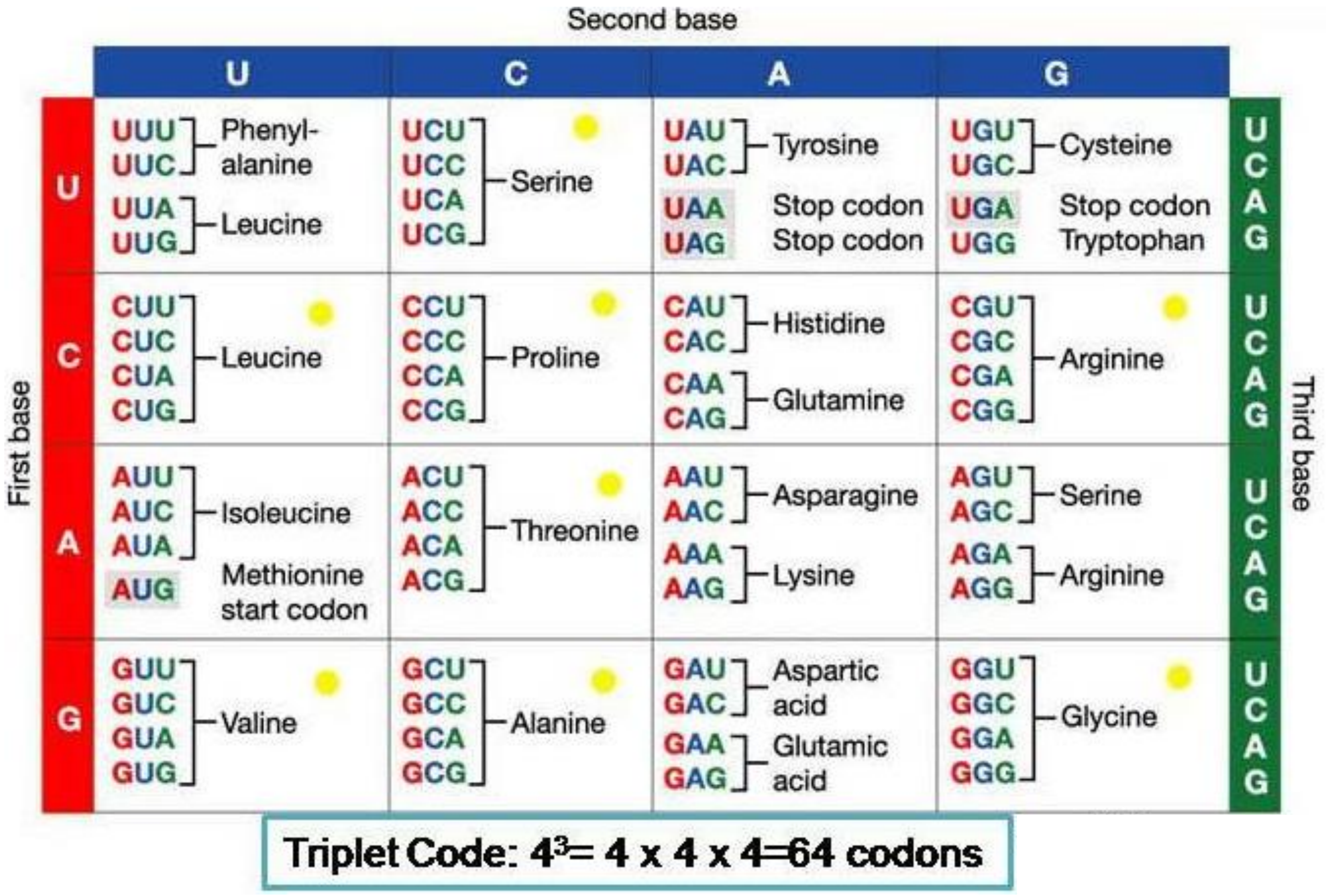
Triplet Code: 4^3= 4 x 4 x 4=64 codons

Ribosome reads the mRNA message:

Phy | Tyr | AGG | GCC | GUA | GAA | UGA



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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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome reads the mRNA message:

Phy | Tyr | Arg | GCC | GUA | GAA | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome reads the mRNA message:

Phy | Tyr | Arg | Ala | GUA | GAA | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome reads the mRNA message:

Phy | Tyr | Arg | Ala | Val | GAA | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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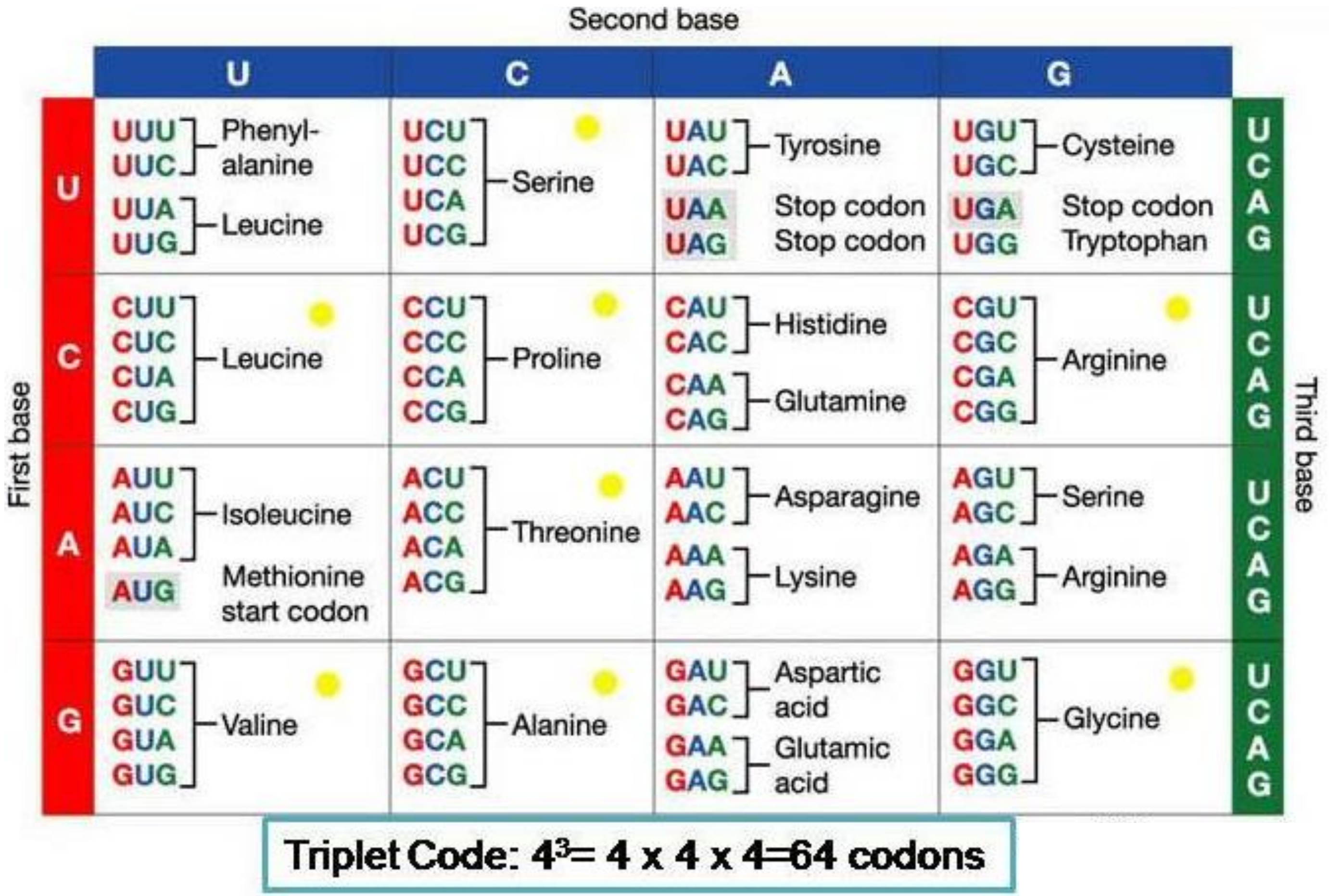
G	GUU, GUC, GUA, GUG – Valine	GCU, GCC, GCA, GCG – Alanine	GAU, GAC – Aspartic acid GAA, GAG – Glutamic acid	GGU, GGC, GGA, GGG – Glycine	U C A G

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

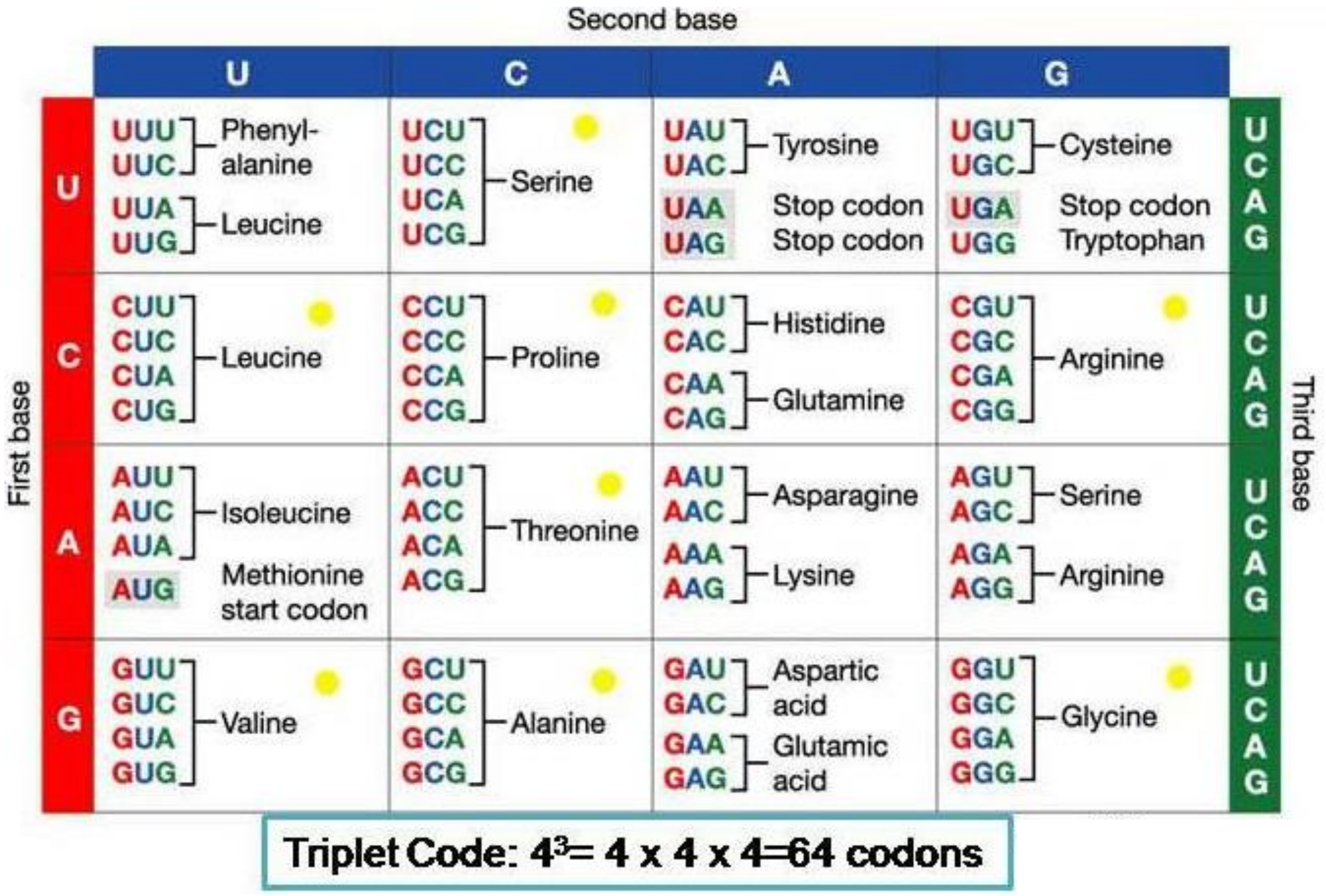
Ribosome reads the mRNA message:

Phy | Tyr | Arg | Ala | Val | Glu | UGA



Ribosome translates to amino acids:

Phy | Tyr | Arg | Ala | Val | Glu | STOP



The protein chain:

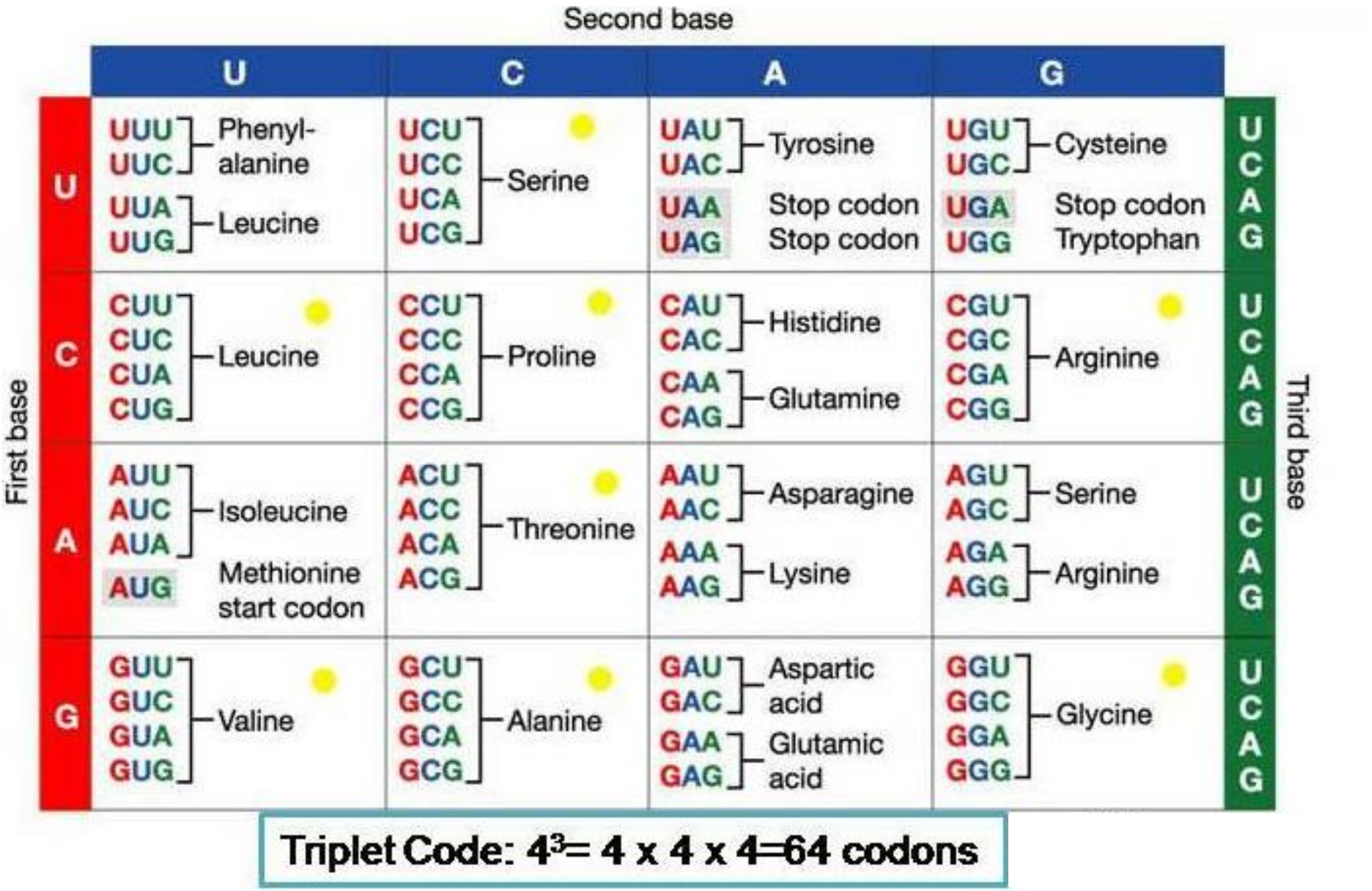
Phy — Tyr — Arg — Ala — Val — Glu

Friday 11/30

P.O.D.

- Use the Codon to Amino Acid chart to translate the following mRNA message...

AUGAAACGAGGGCUGUUUCGAAAAUGA



Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

AUG | AAA | CGA | GGG | CUG | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | AAA | CGA | GGG | CUG | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC — Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | Lys | CGA | GGG | CUG | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | Lys | Arg | GGG | CUG | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | Lys | Arg | Gly | CUG | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | Lys | Arg | Gly | Leu | UUU | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine; 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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

P.O.D.

Met | Lys | Arg | Gly | Leu | Phy | CGA | AAU | UGA

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

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Met | Lys | Arg | Gly | Leu | Phy | Arg | AAU | UGA

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First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

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Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

P.O.D.

Met | Lys | Arg | Gly | Leu | Phy | Arg | Asp | STOP

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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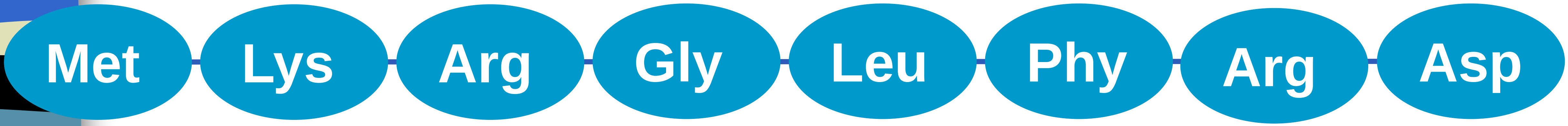
P.O.D.

Met | Lys | Arg | Gly | Leu | Phy | Arg | Asp | STOP



The START codon corresponds with Methionine

But

The STOP codon does not correspond with an amino acid

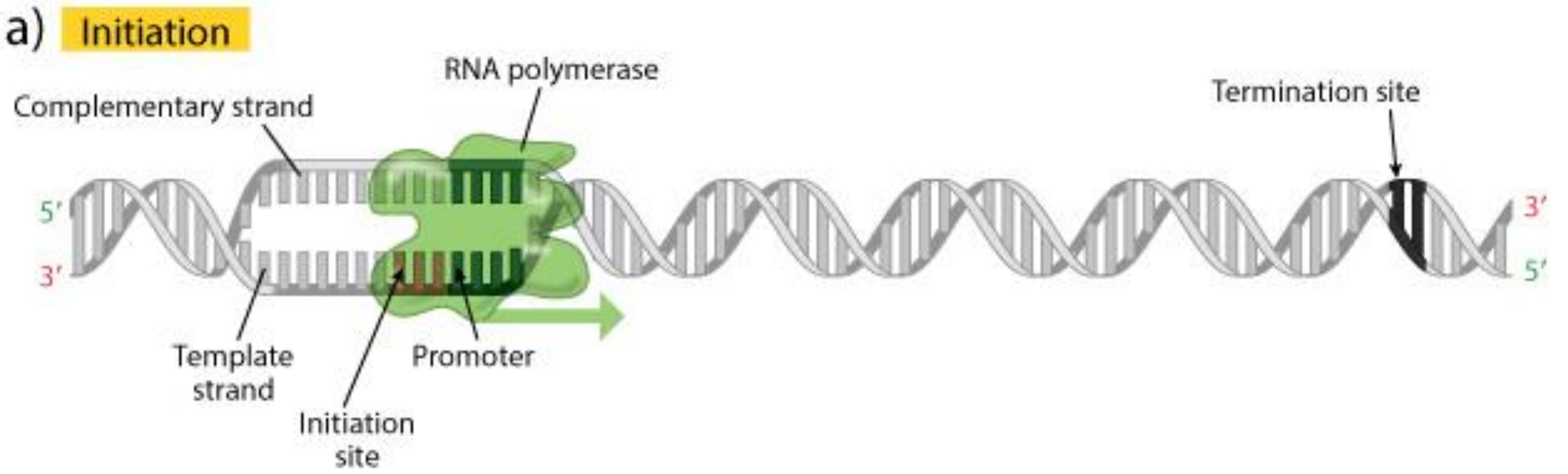
Reminders

- Next week
  - Monday December 3rd – Unit 5 Vocabulary Quiz
  - Monday December 3rd *AFTER SCHOOL* Unit 4 Makeups (Quiz, Exam, Practical)
  - Tuesday December 4th – Unit 5 Exam
  - Wednesday December 5th – Prefix/Suffix Quiz #6
  - Thursday December 6th – Unit 5 Practical Test

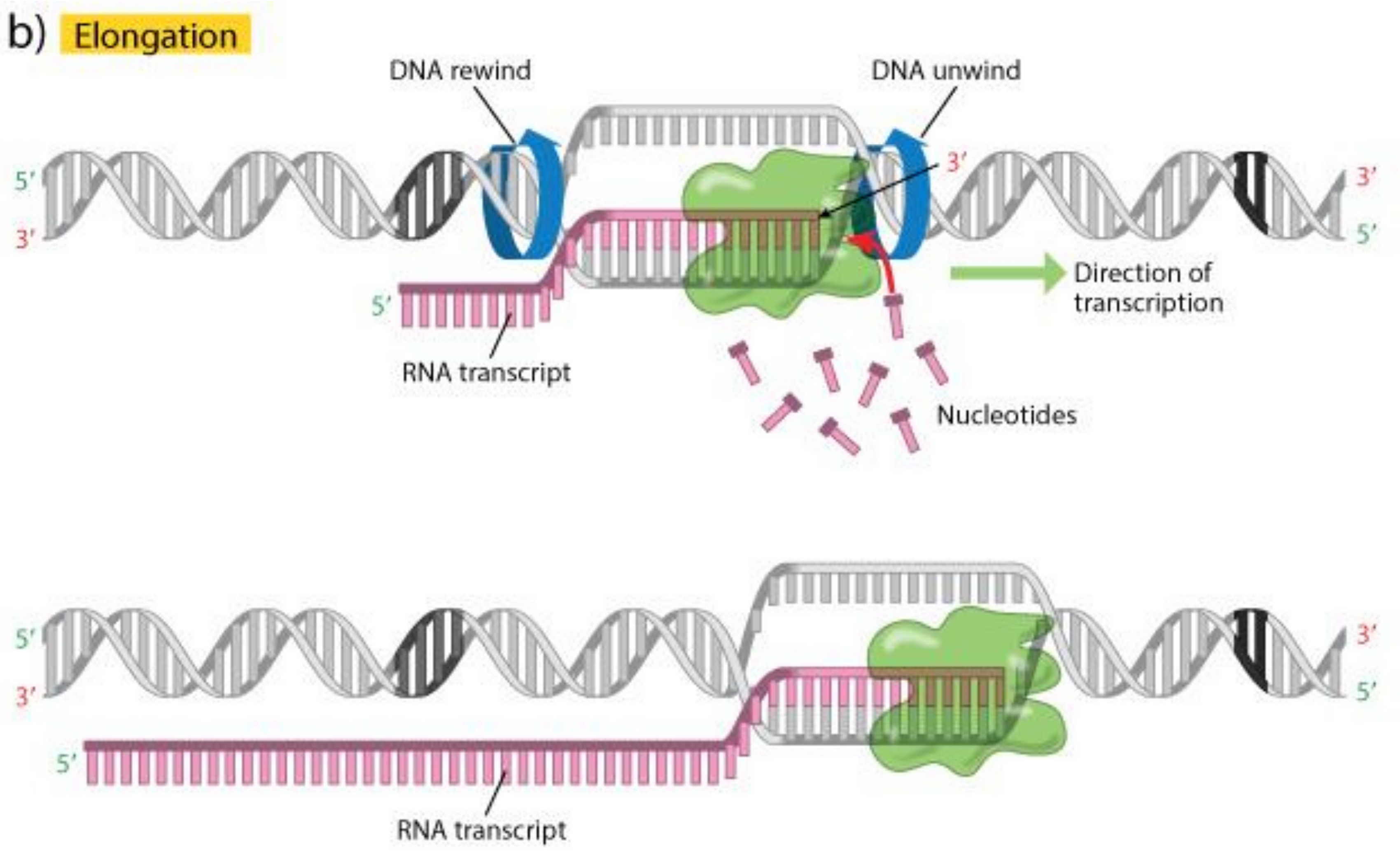
Transcription

- The first step of cells ‘reading’ the instructions in DNA and carrying them out
  - The goal is to make an RNA copy of a gene’s DNA sequence
    - Cells do transcription with single genes and groups of genes, not with an organisms’ whole genome

RNA polymerase binds to the START codon at the beginning of the gene and then separates the DNA strands and exposes a single-strand of DNA that will serve as a template

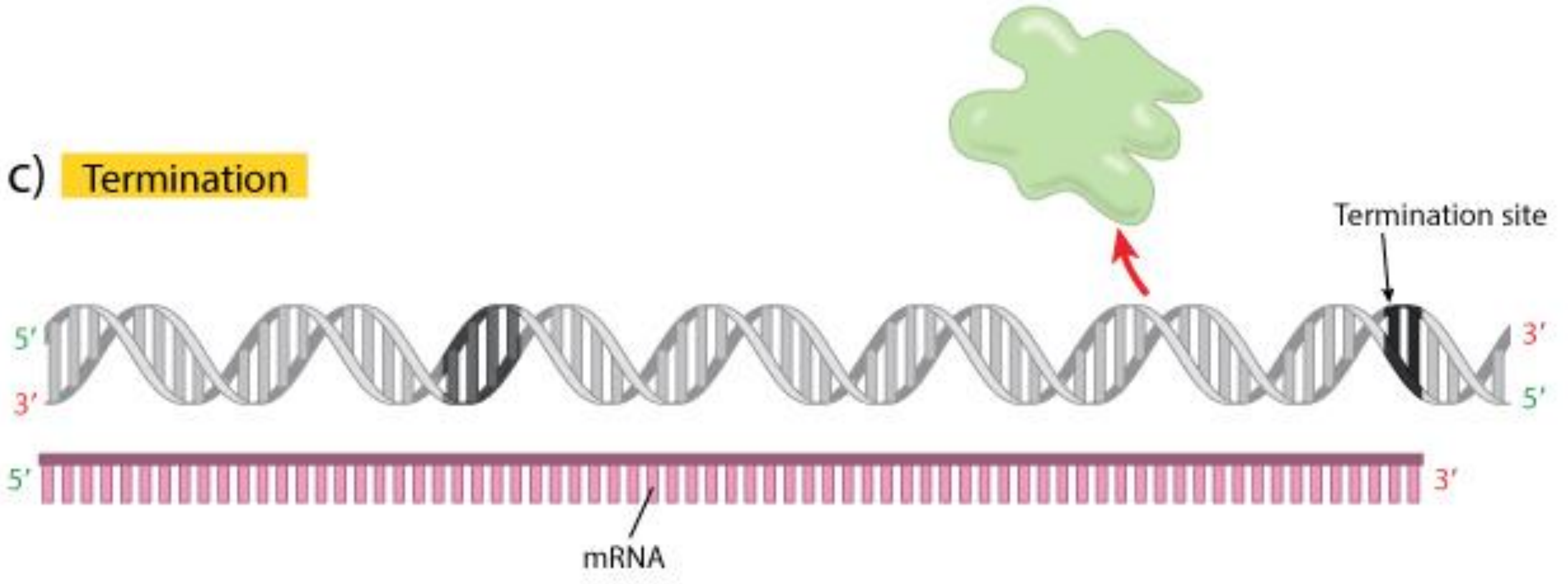


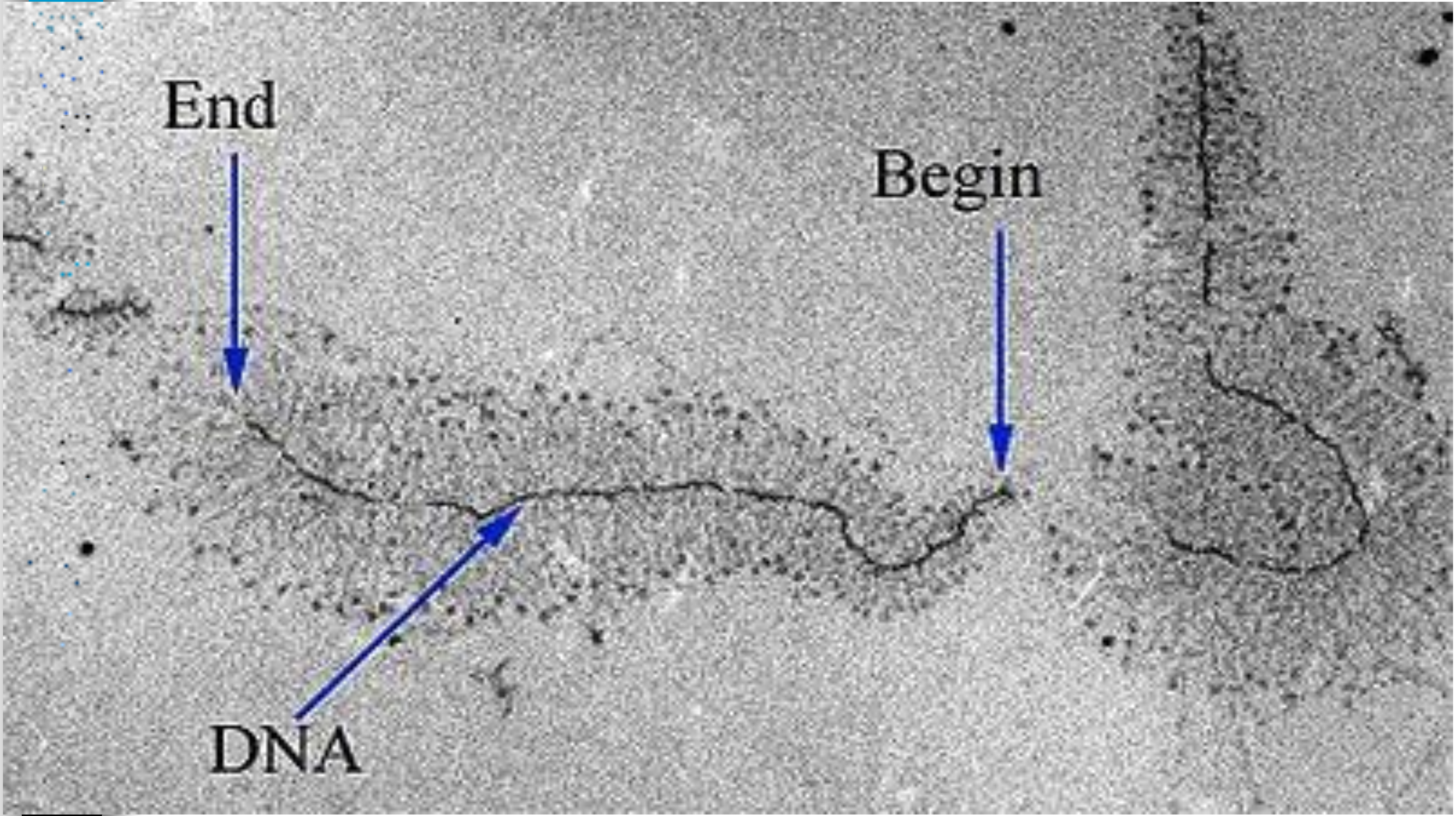
RNA polymerase “reads” the template strand of the gene one base at a time and then builds an RNA copy by adding complementary bases



RNA polymerase “reads” the STOP codon and the RNA transcript is complete

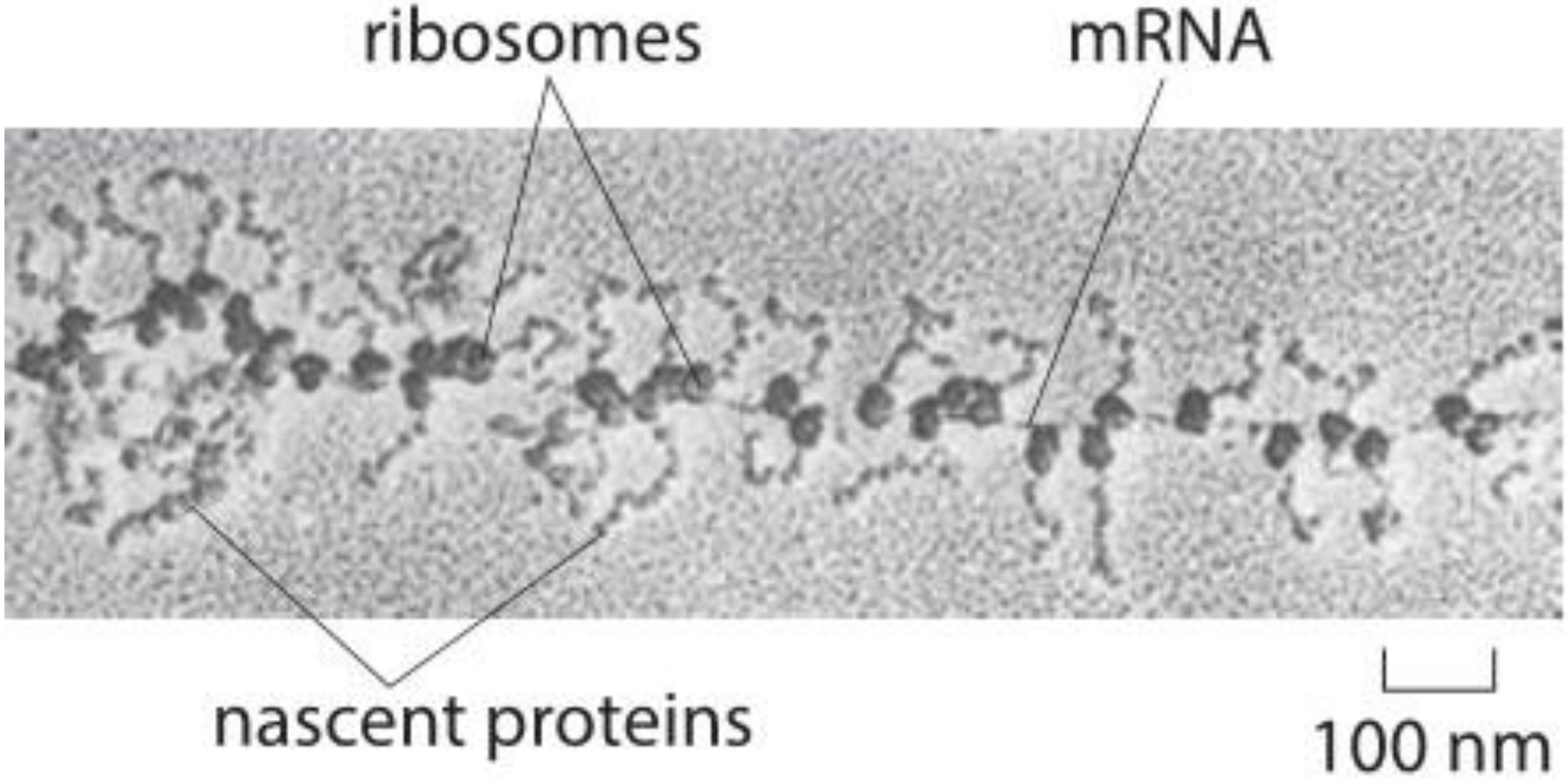
This is called mRNA




End
Begin
DNA

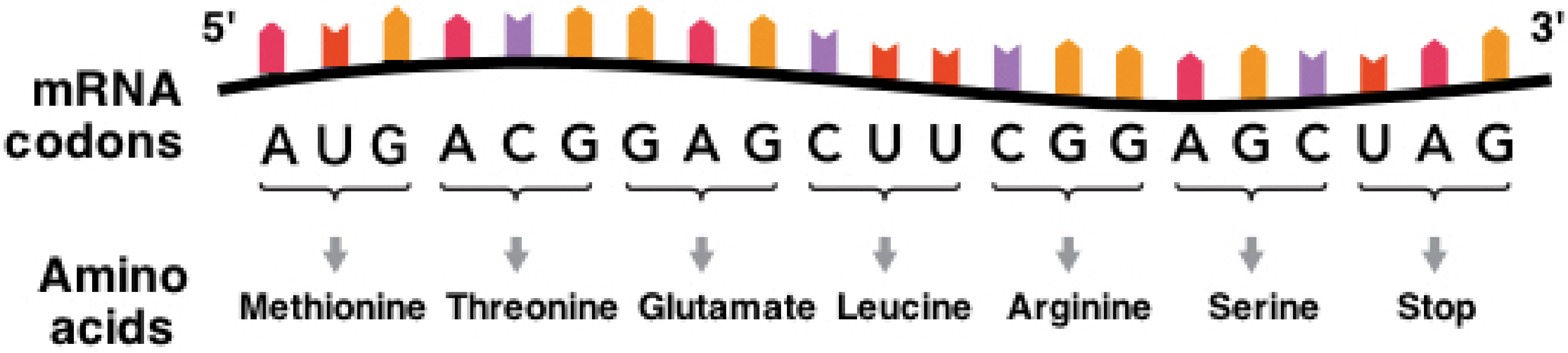
Translation

- This strand of mRNA leaves the nucleus and carries its message to the ribosome



Translation

- After the mRNA is complete, it travels to the ribosomes where the mRNA is read codon by codon
  - As each codon is read, the corresponding amino acid is bonded



Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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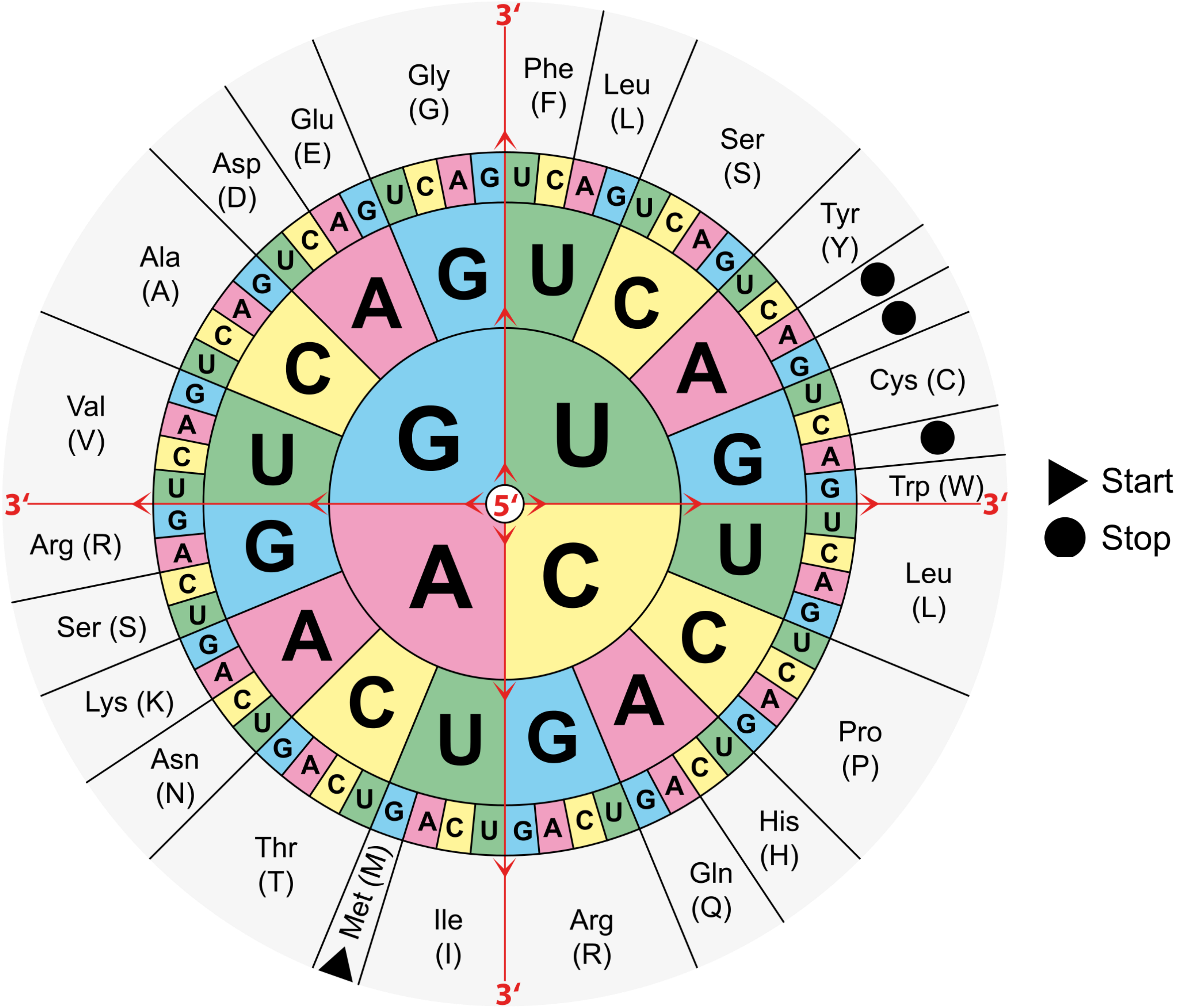
A	AUU, AUC, AUA – Isoleucine AUG Methionine start codon	ACU, ACC, ACA, ACG – Threonine	AAU, AAC – Asparagine AAA, AAG – Lysine	AGU, AGC – Serine AGA, AGG – Arginine	U C A G
G	GUU, GUC, GUA, GUG – Valine	GCU, GCC, GCA, GCG – Alanine	GAU, GAC – Aspartic acid GAA, GAG – Glutamic acid	GGU, GGC, GGA, GGG – Glycine	U C A G

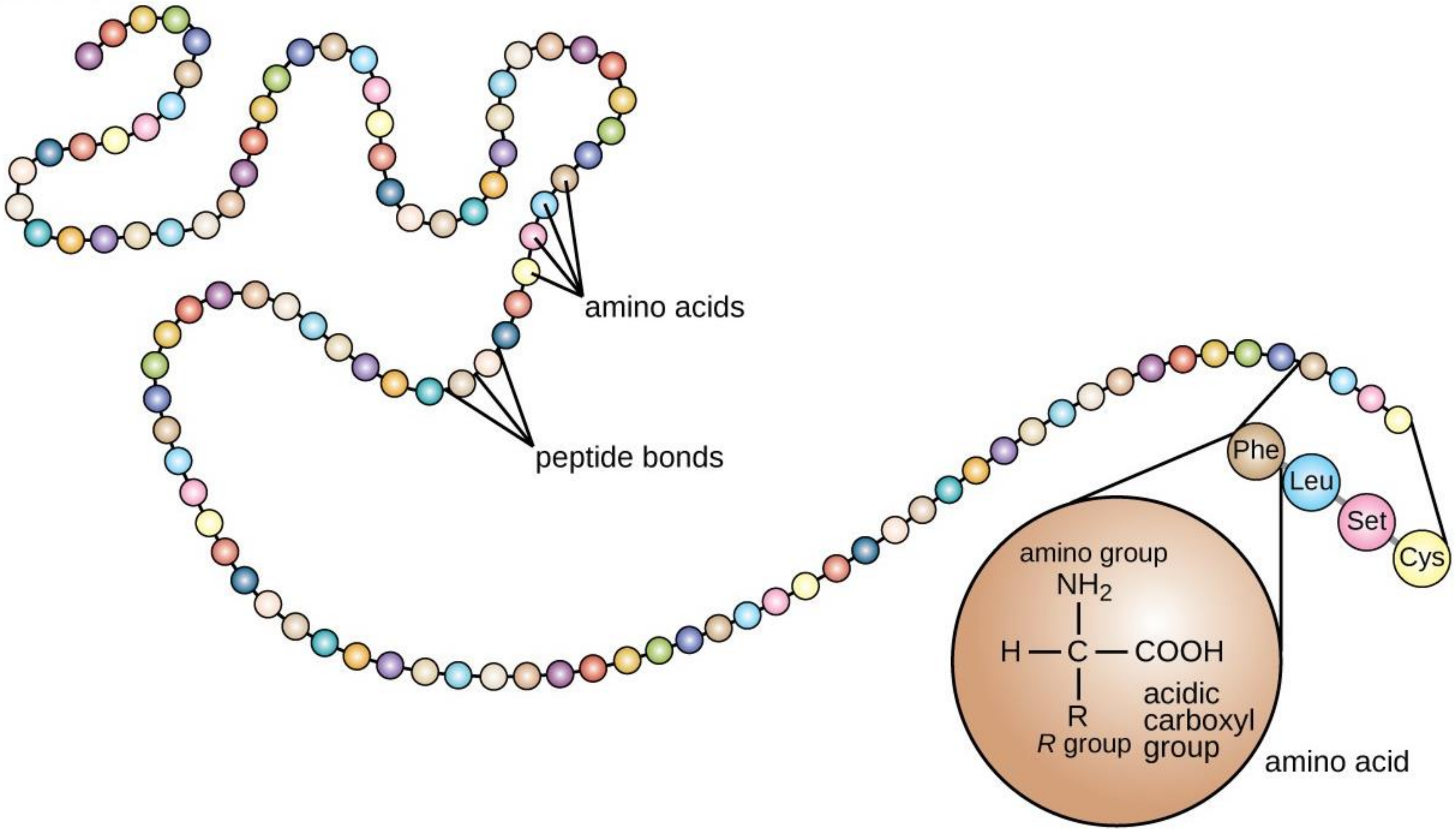
Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons



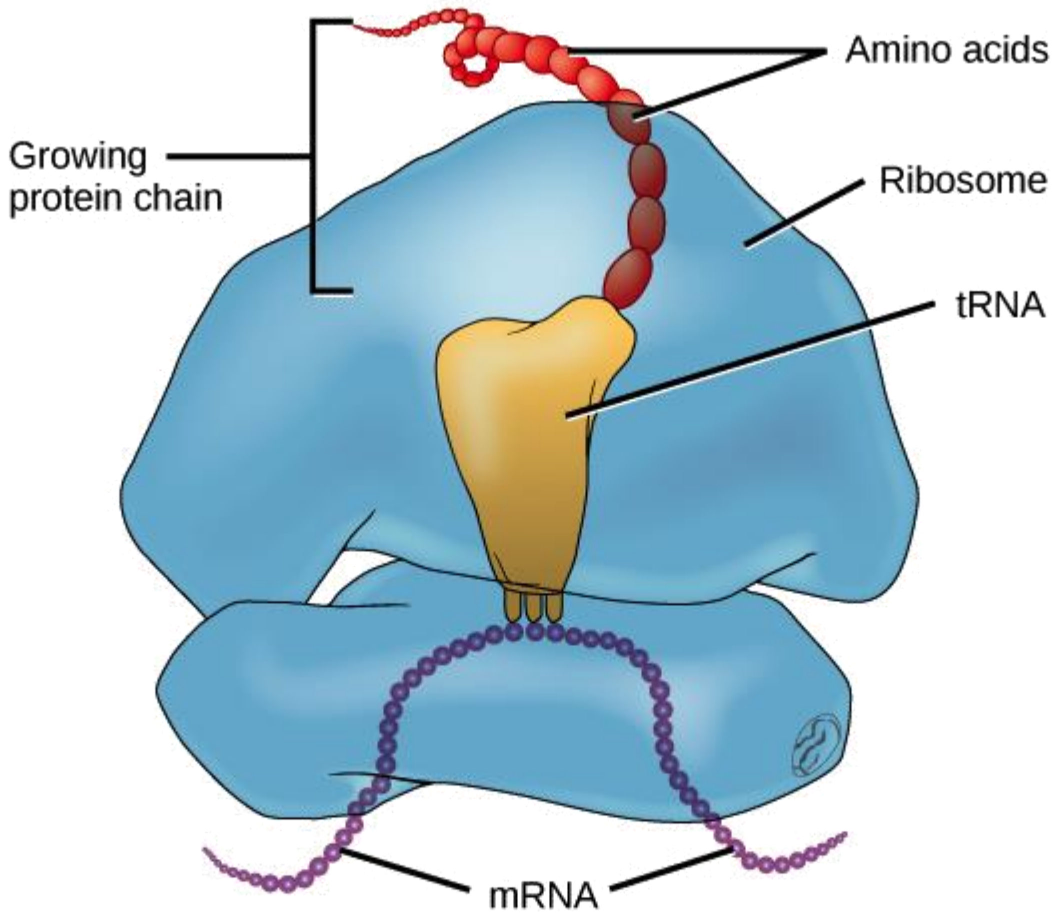
3'
5'
Phe (F)
Leu (L)
Ser (S)
Tyr (Y)
Cys (C)
Trp (W)
Leu (L)
Pro (P)
His (H)
Gln (Q)
Arg (R)
Ile (I)
Met (M)
Thr (T)
Asn (N)
Lys (K)
Ser (S)
Arg (R)
Val (V)
Ala (A)
Asp (D)
Glu (E)
Gly (G)
Start
Stop

Translation

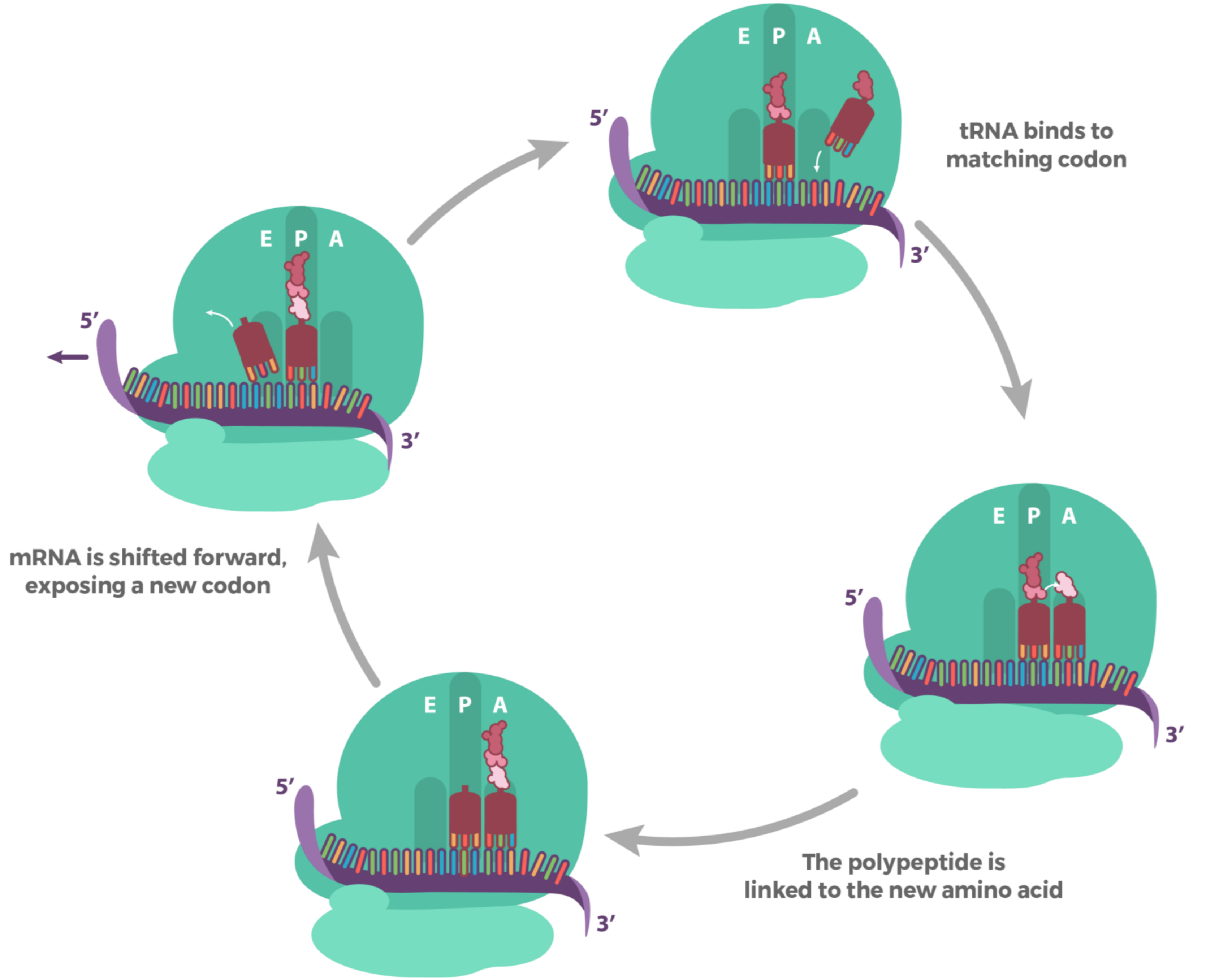
- A chain of amino acids forms the peptide (protein) that the gene that was transcribed/translated coded for



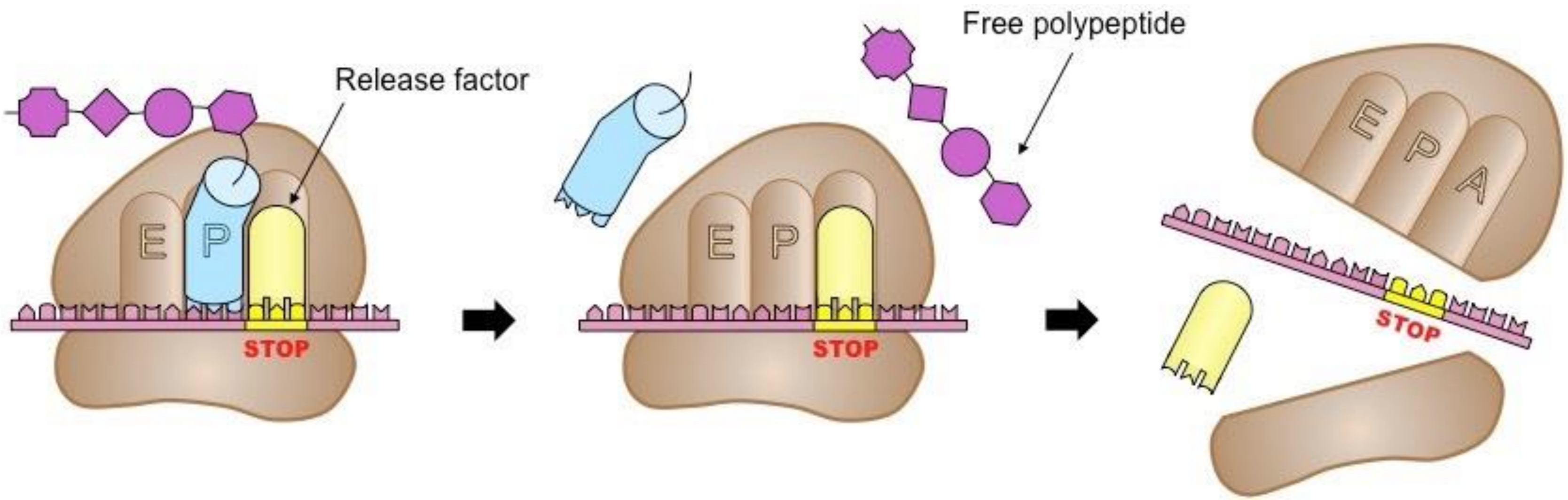
A ribosome assembles around the mRNA and a tRNA carrying the START amino acid



Then, the ribosome reads the codons one at a time (3 base pairs at a time) and tRNA brings in the corresponding amino acids, adding them to the protein chain



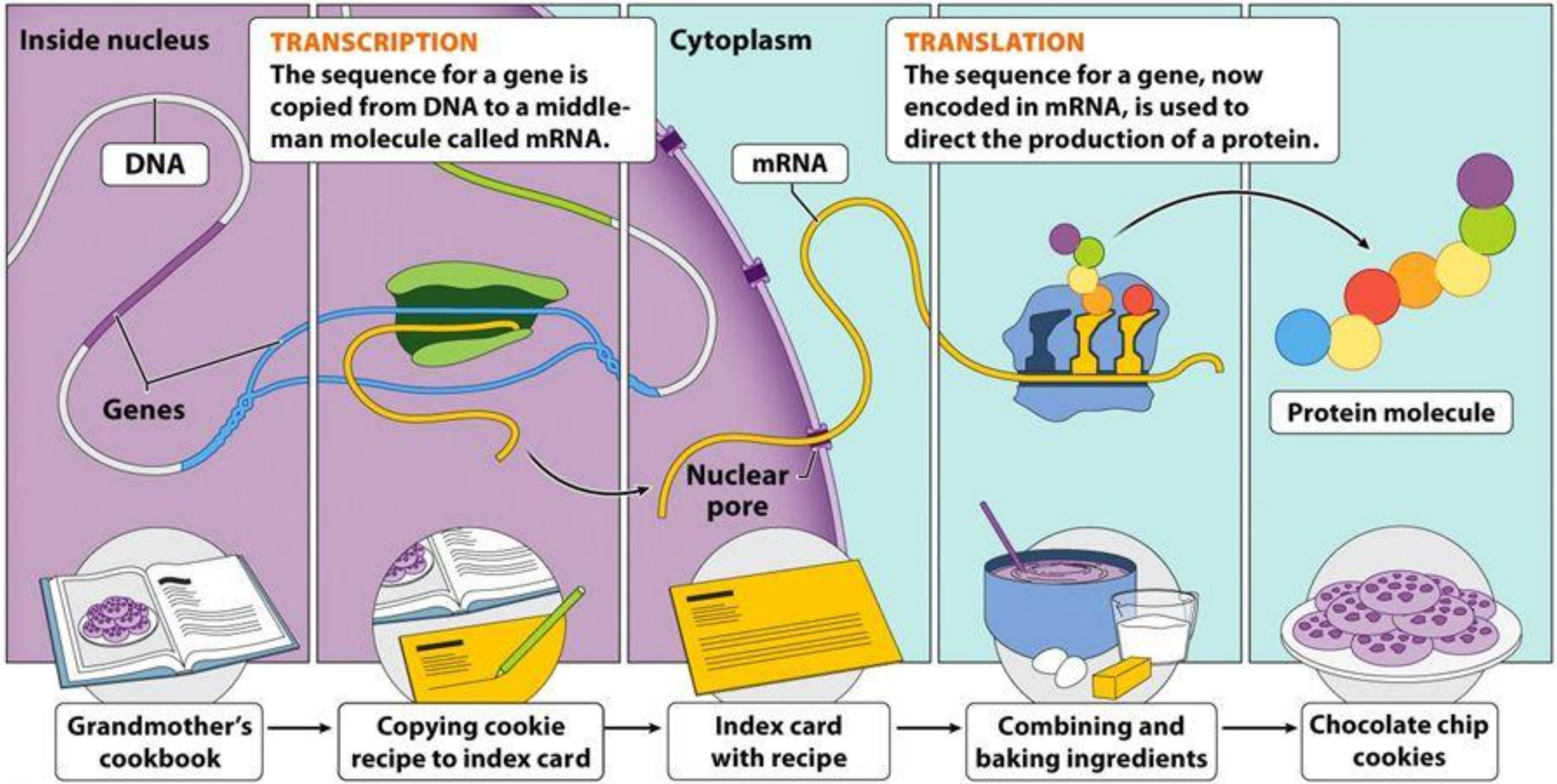
When the ribosome reads a STOP codon, the protein chain separates from the mRNA and ribosome



Translation

- After a newly synthesized protein chain gets released, it may still need to
  - Fold into the right shape
  - Undergo processing
  - Get shipped to the correct place in the cell
  - Combine with other protein chains

How to think about all this….


Inside nucleus
TRANSCRIPTION
The sequence for a gene is copied from DNA to a middle-man molecule called mRNA.
Cytoplasm
TRANSLATION
The sequence for a gene, now encoded in mRNA, is used to direct the production of a protein.
DNA
mRNA
Genes
Nuclear pore
Protein molecule
Grandmother's cookbook
Copying cookie recipe to index card
Index card with recipe
Combining and baking ingredients
Chocolate chip cookies

Watson & Crick's
4 Criteria

Criteria 1

The molecule must be able to store A LOT of information

- How does DNA store information?

Criteria 2

The molecule must be able to copy itself with great precision

- Why is this important?
- How is it done?

Criteria 3

The molecule must be able to make mistakes when being copied

- Why are mistakes important?
- How can DNA make mistakes?

Criteria 4

The molecule must be readable by cells

- How does the cell "read" the DNA?
- What does it do with the information?
- What is transcription?
- What is translation?

Transcription
&
Translation
Practice

Steps:

(1) Transcribe DNA using mRNA

- Remember: RNA has U and no T

(2) Group the mRNA into codons

- Groups of 3

(3) Translate mRNA into amino acids

- Use the chart

(4) String the amino acids together in to a protein chain

- The START codon corresponds to an amino acid but the STOP codon does not

DNA sequence – a gene

ATGTCTACTAATGGGAGTTACTTAGAGTAG

Second base

First base	U	C	A	G	Third base
U	UUU UUC — Phenyl-alanine 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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

mRNA – transcription of DNA

AUGUCUACUAAUGGGAGUUACUUAGAGUAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

mRNA – transcription of DNA

AUG | UCU | ACU | AAU | GGG | AGU | UAC | UUA | GAG | UAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome translates codon to amino acids

Met | UCU | ACU | AAU | GGG | AGU | UAC | UUA | GAG | UAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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
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Triplet Code: 4^3= 4 x 4 x 4=64 codons

Ribosome translates codon to amino acids

Met | Ser | ACU | AAU | GGG | AGU | UAC | UUA | GAG | UAG

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Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome translates codon to amino acids

Met | Ser | Thr | AAU | GGG | AGU | UAC | UUA | GAG | UAG

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First base	U	C	A	G	Third base
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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
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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

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Ribosome translates codon to amino acids

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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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome translates codon to amino acids

Met | Ser | Thr | Asp | Gly | Ser | Tyr | UUA | GAG | UAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC — Phenyl-alanine 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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

Ribosome translates codon to amino acids

Met | Ser | Thr | Asp | Gly | Ser | Tyr | Leu | GAG | UAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: 4^3= 4 x 4 x 4=64 codons

Ribosome translates codon to amino acids

Met | Ser | Thr | Asp | Gly | Ser | Tyr | Leu | Glu | UAG

Second base

First base	U	C	A	G	Third base
U	UUU, UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

Ribosome translates codon to amino acids

Met | Ser | Thr | Asp | Gly | Ser | Tyr | Leu | Glu | STOP

Second base

First base	U	C	A	G	Third base
U	UUU UUC – Phenyl-alanine 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

Triplet Code: $4^3 = 4 \times 4 \times 4 = 64$ codons

String amino acids together into a protein chain

Met | Ser | Thr | Asp | Gly | Ser | Tyr | Leu | Glu | STOP

Transcribe and Translate the following messages:

1. ATGGTTAATCCCCACCGATTTTGTTTGAAGTGA
2. ATGCATGAGGGGTTTCTTATTGTGAATAAATAG
3. ATGTATCGCAGTGATGTTCTTCCAGGCGGGTAA

Work your way back to the original DNA message

1. Met-Thr-Ala-Tyr-Asp-Ser-Gly-Iso-Leu-Val-STOP
2. Met-Pro-Ser-Cys-Gly-Asp-Ala-Phy-Ser-Pro-STOP
3. Met-Arg-Cys-Ser-Pro-Thr-Gly-Iso-Leu-Glu-STOP