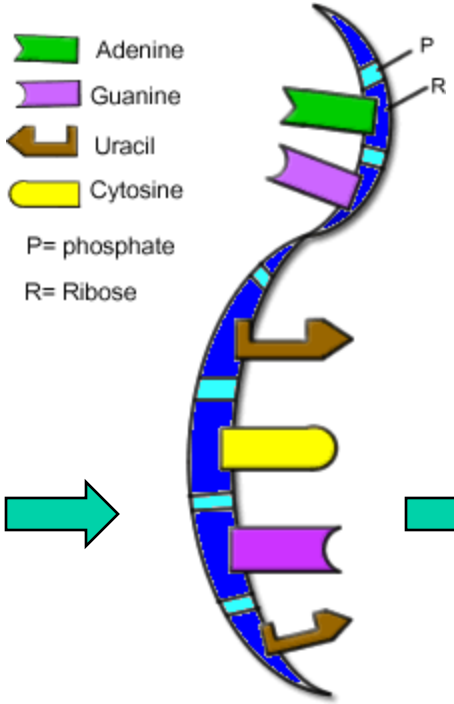
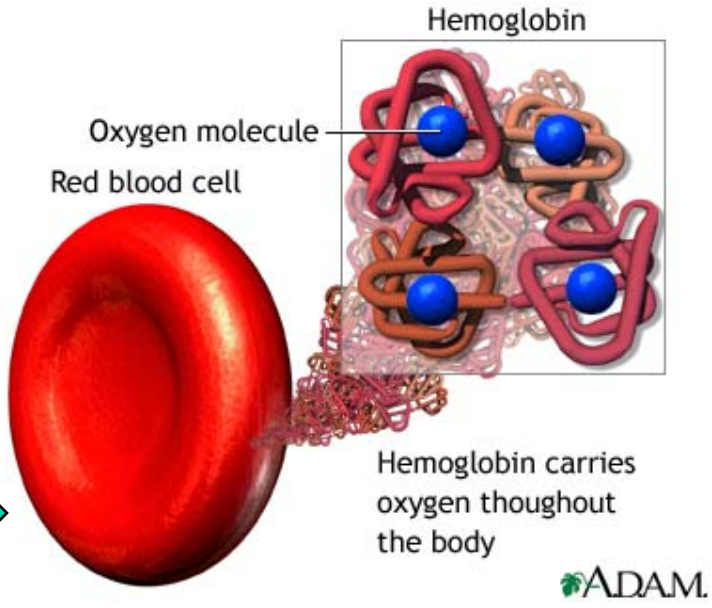
Protein Synthesis



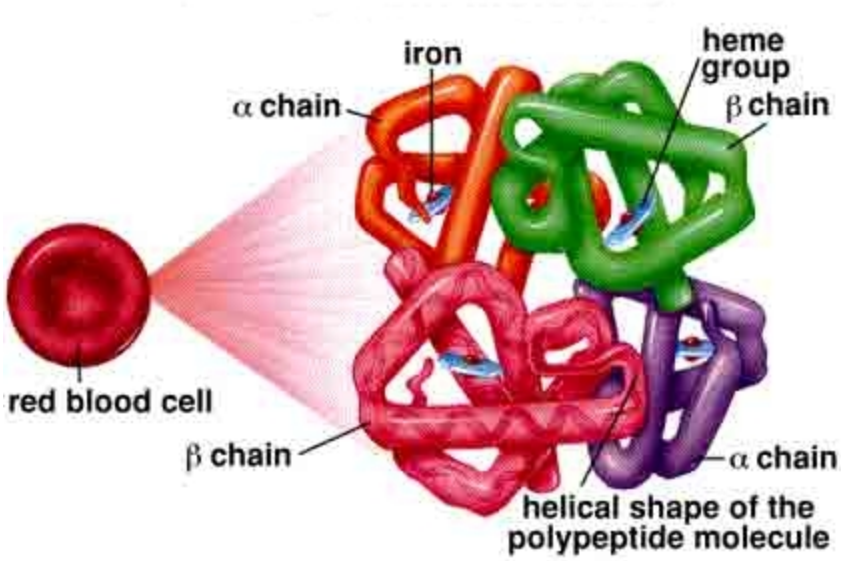


Proteins in the Body

DNA is found in almost all living organisms and directs **protein synthesis**

Examples of protein are:

- Enzymes (ex. lactase)
- Hormones (ex. insulin)
- Antibodies
- Hemoglobin
- Cell membranes
- Receptor molecules



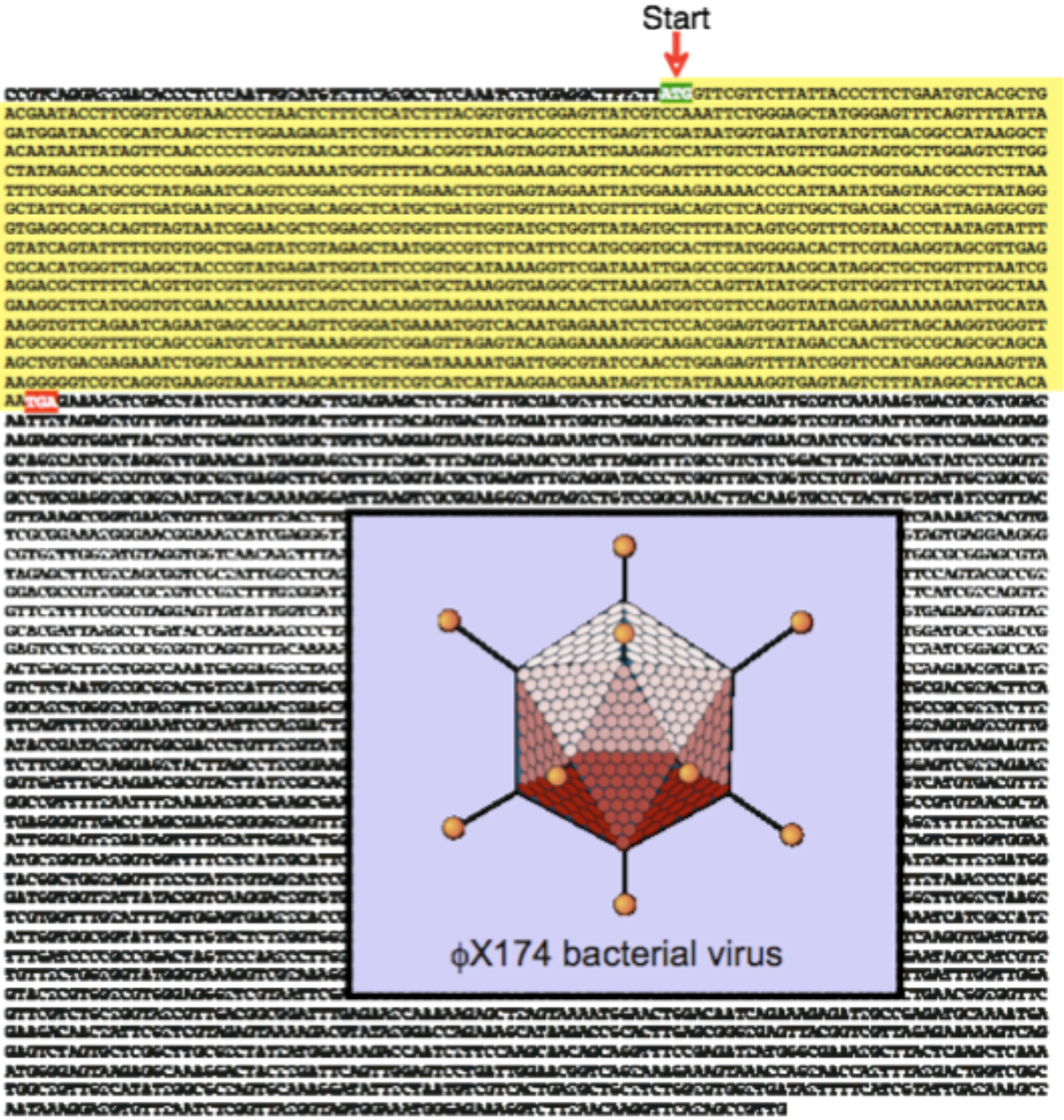
Protein Synthesis

This is the complete genome of oX174 bacterial virus.

It has **9 genes=(9 proteins)**

The **highlighted section is 1 gene**

The human genome is 1 million times larger than this



What are proteins made of?

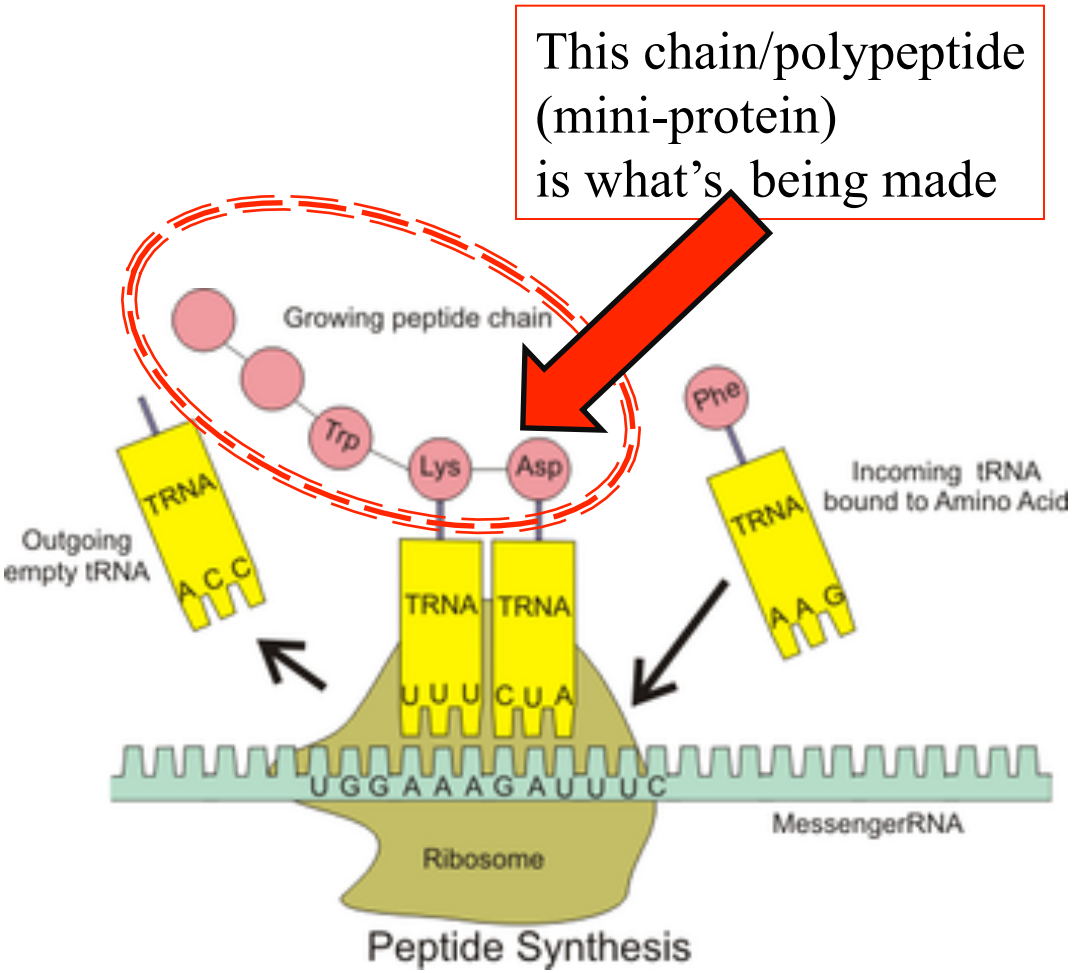
- Proteins are made up of **20** different **amino acids**

Different combinations of amino acids = **different protein produced**

- The amino acids formed are determined by the base sequence in our **DNA**

- <u>One gene = one protein</u>

- Protein Synthesis relies on 3 types of RNA
  - **rRNA**
  - **mRNA**
  - **tRNA**



DNA vs. mRNA

- Location: nucleus (and **cytoplasm** during cell division)
- Strand number:

  Double stranded

- Sugar: deoxyribose

  Nitrogen Bases: 4

  C, G, A, **T**hymine

- Location: nucleus and cytoplasm
- Strand number:

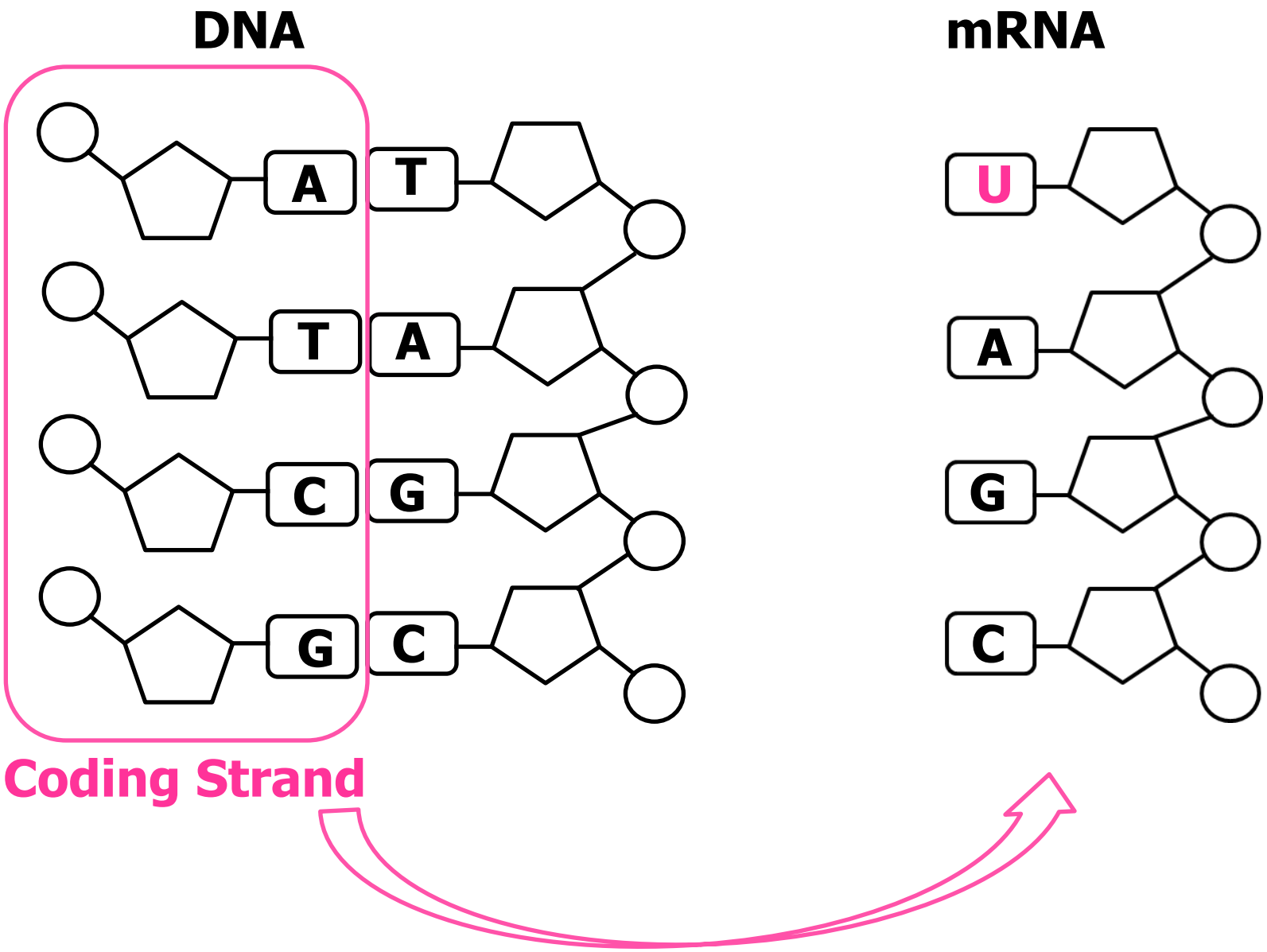
  Single stranded

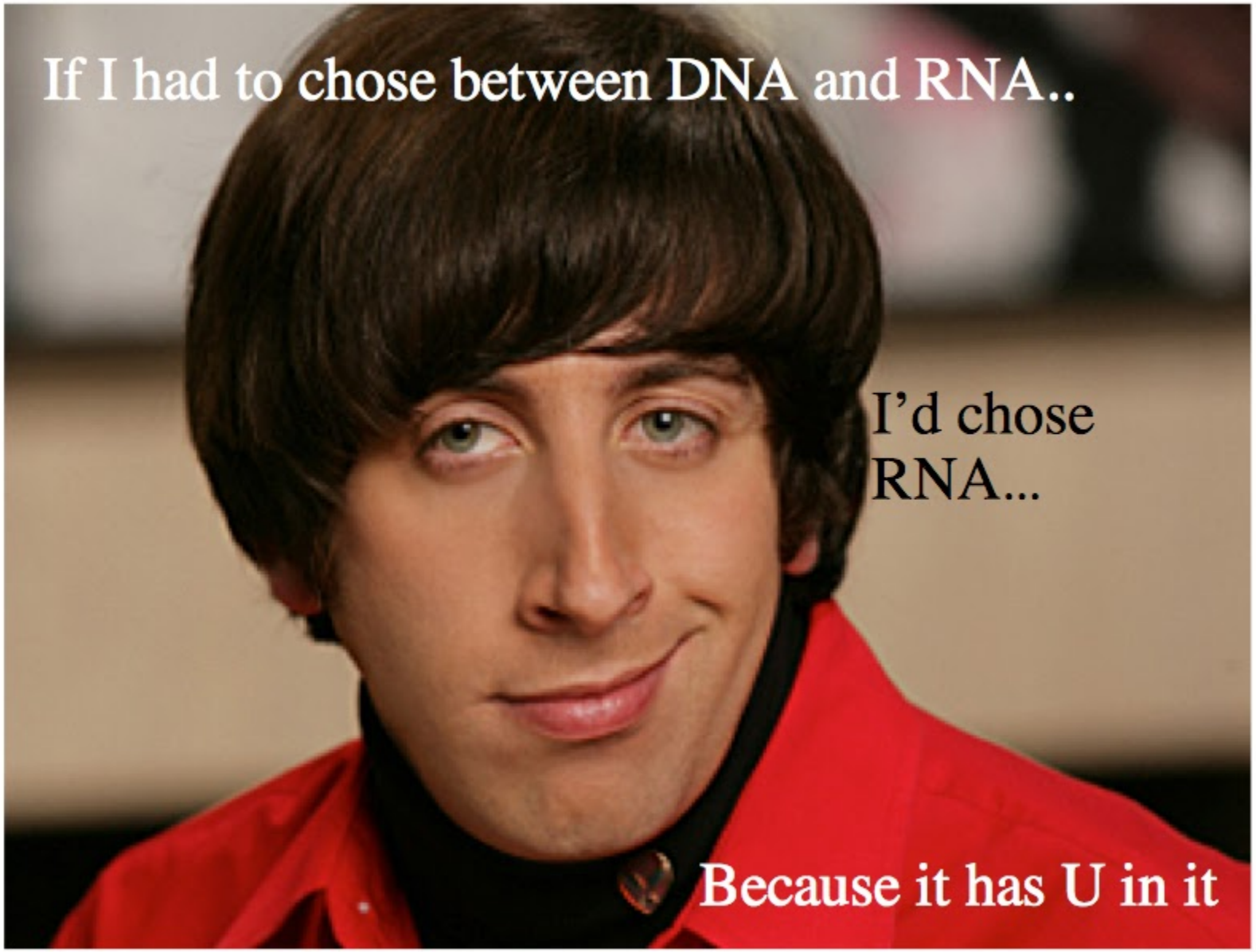
- Sugar: ribose

  Nitrogen Bases: 4

  – C, G, A, **U**racil

Nucleic Acids



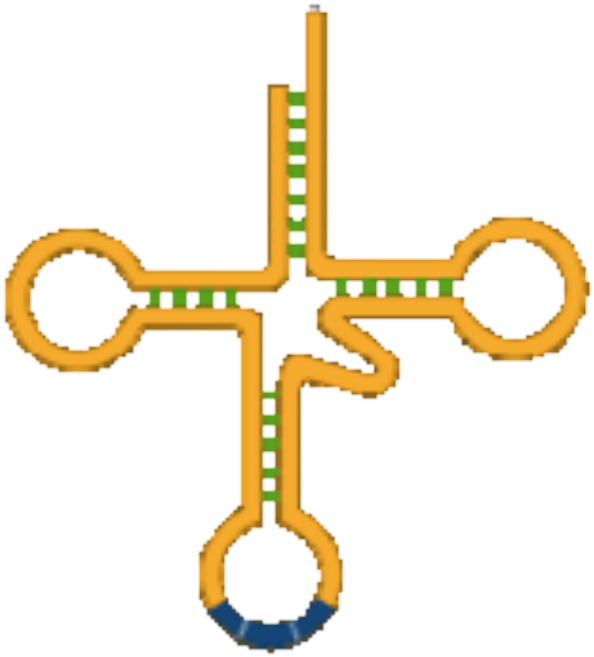

If I had to chose between DNA and RNA..
I'd chose RNA...
Because it has U in it

Types of RNA

Type of RNA	Its Role	Where Located
Messenger RNA (mRNA)	-Involved in Transcription (first stage of protein synthesis) -"Photocopies" the DNA and carries message from DNA in nucleus to ribosome in cytoplasm	In cytoplasm & nucleus
Ribosomal RNA (rRNA)	Makes up the ribosomes which are the "factories" that make the proteins	In cytoplasm
Transfer RNA (tRNA)	Carries or transports the amino acids to mRNA to be turned into a protein	In cytoplasm

Types of RNA

mRNA



tRNA

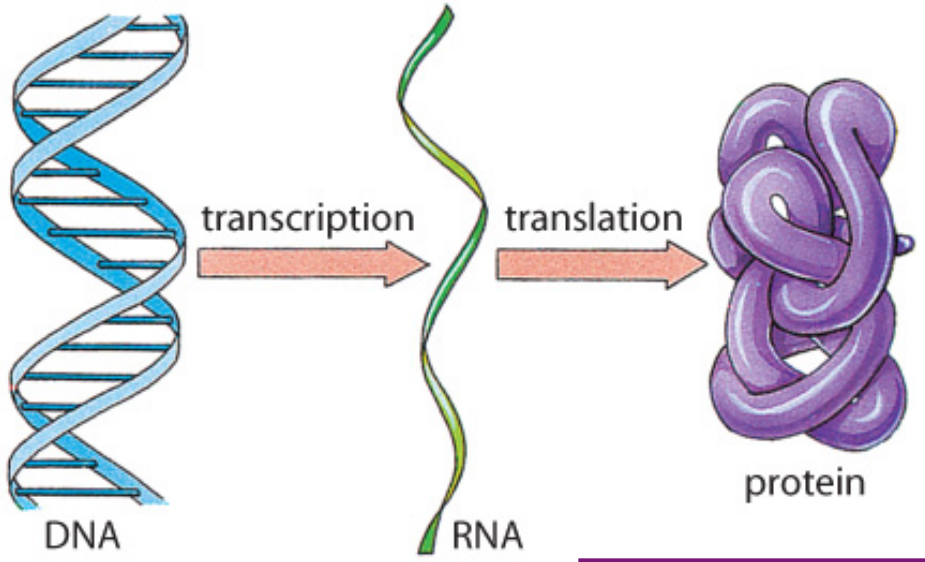
Ribosomes

Protein Synthesis

- Occurs primarily in **ribosomes "the protein factories"**
- Instructions for protein contained in **DNA** (cookbook)
- Message must get from **nucleus** to **cytoplasm** (DNA to ribosome)
- Process occurs in 2 steps:

1. Transcription

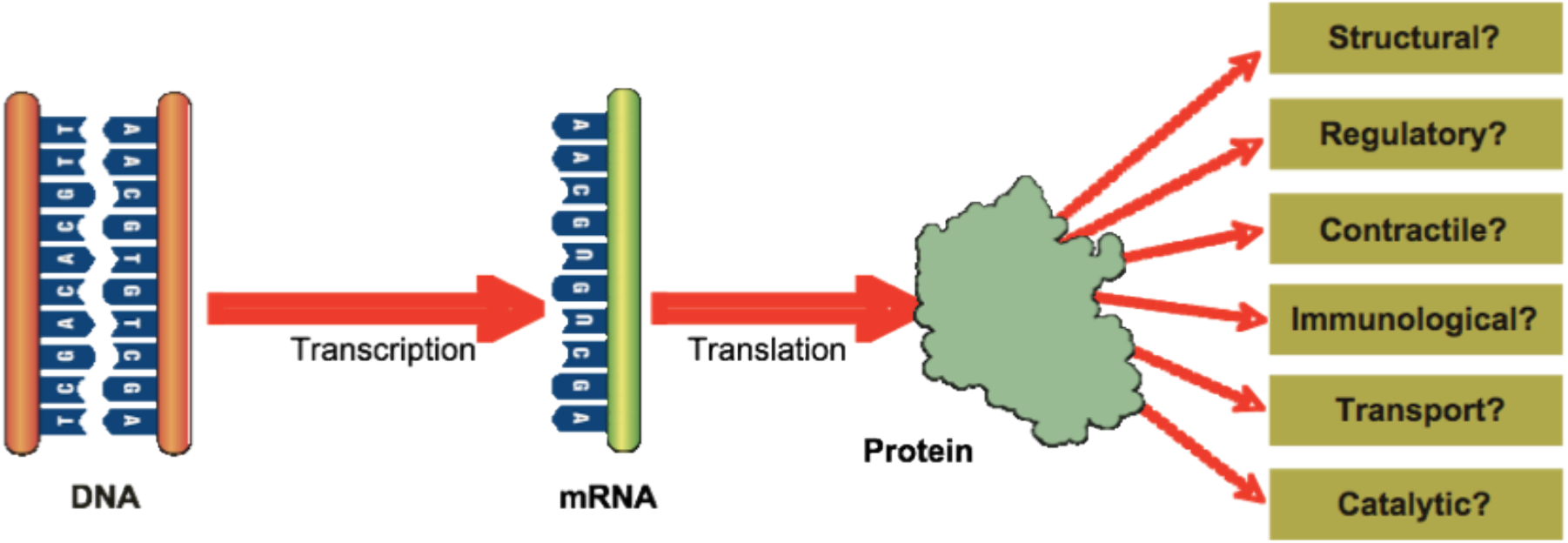
2. Translation



In nucleus

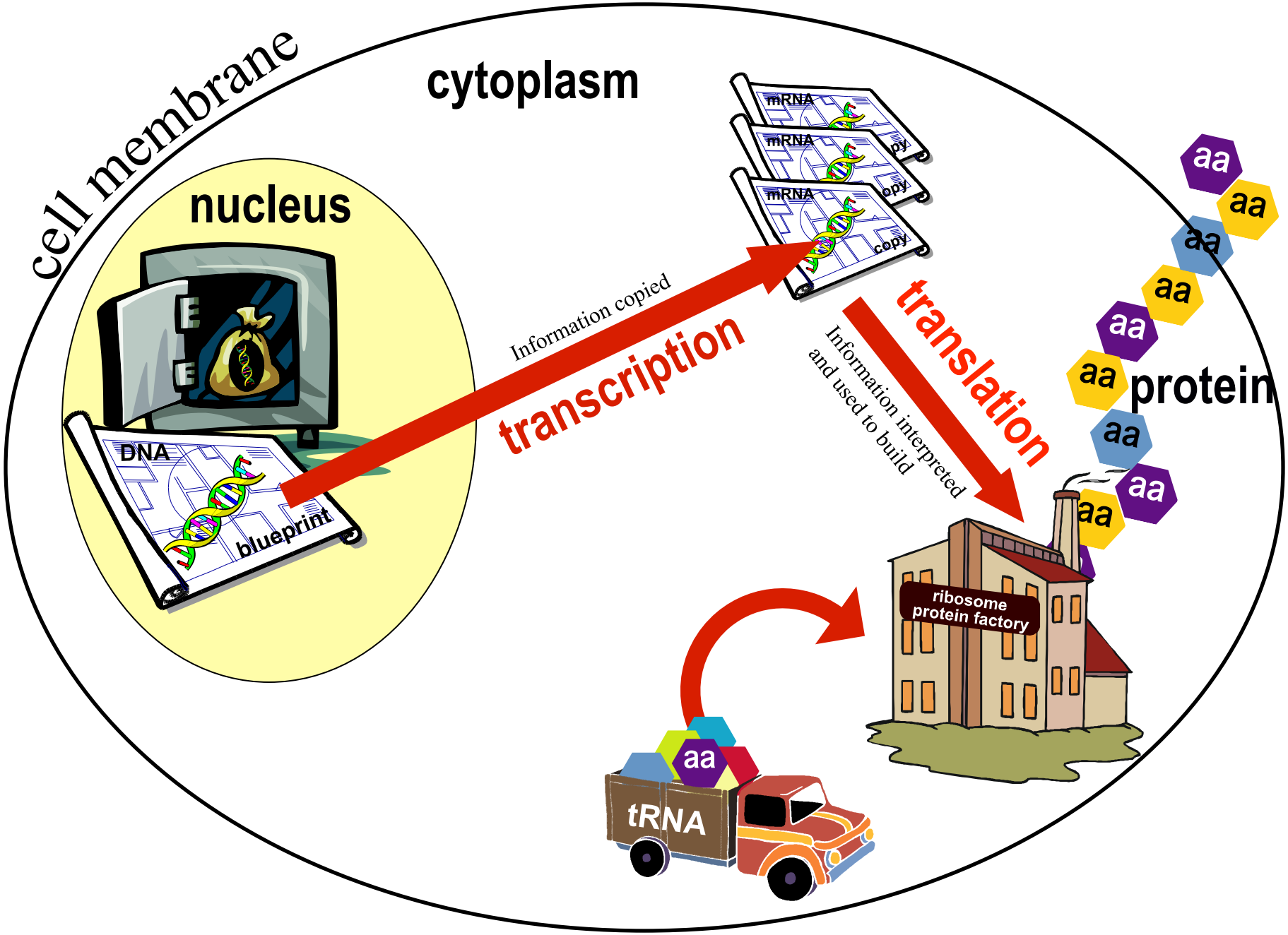
In cytoplasm

Protein Synthesis…AN OVERVIEW



Occurs in nucleus

Occurs in Cytoplasm


cell membrane
cytoplasm
nucleus
DNA
blueprint
Information copied
transcription
mRNA
mRNA
mRNA
copy
copy
copy
Information interpreted
and used to build
translation
aa
aa
aa
aa
aa
aa
aa
aa
protein
ribosome
protein factory
aa
tRNA

Step1: Transcription

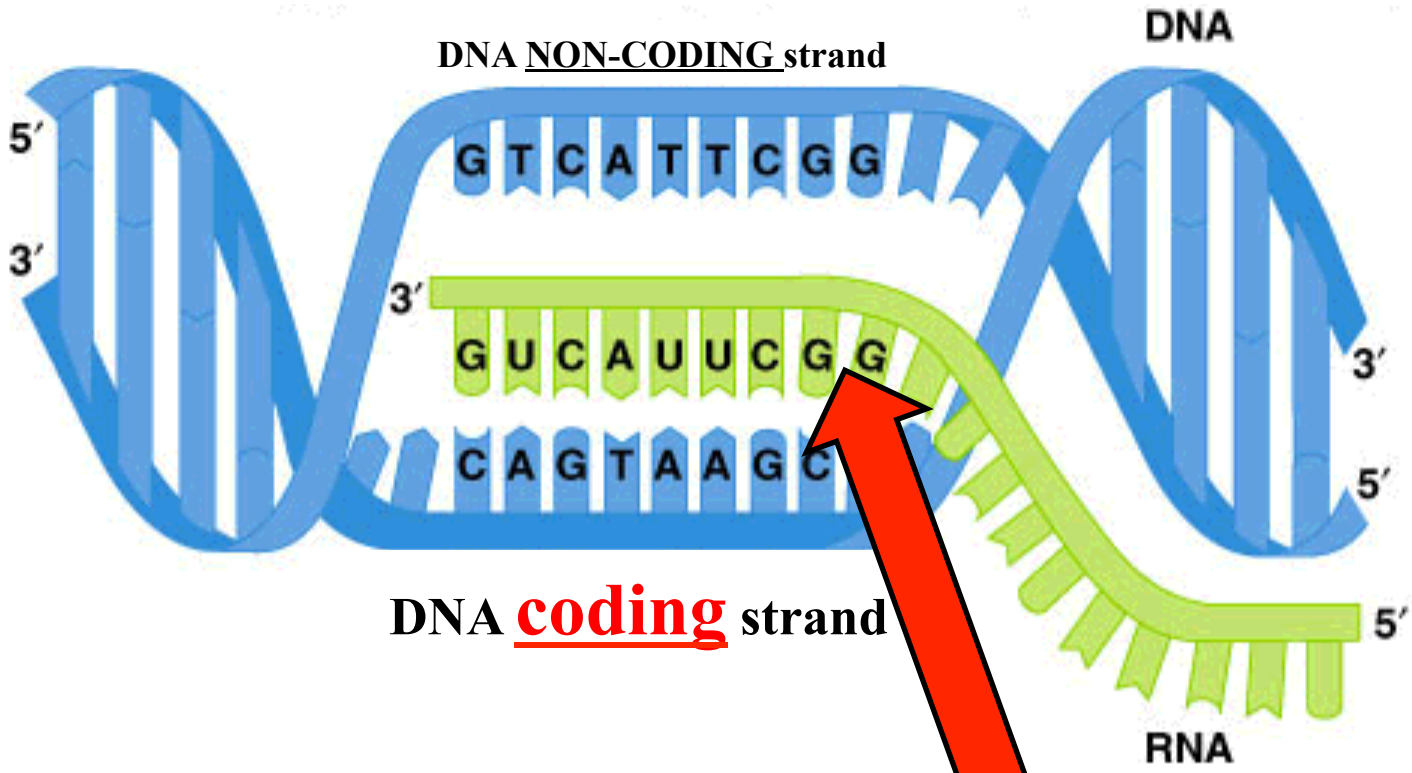
- Occurs in the nucleus
- ***mRNA*** makes a (photocopy) using **DNA as a template**
- If the **DNA** base sequence is

  A A T T C C (these are called **DNA triplets**)
- The **mRNA** molecule manufactured would be

  U U A A G G (these are called **codons**)
- Each **DNA triplet** has a complementary **codon** (on the mRNA)
- mRNA **exits nucleus**

Code must be transcribed then translated

Transcription Animation



Transcription

DNA used as template to build mRNA

Practice:

DNA Strand: A T G G T C T C G

mRNA Strand: **U A C C A G A G C**

How many triplets or codons are there? **3**

Codons

- Each codon **codes for an amino acid**(building block)

  (REMEMBER: codon = set of 3 nucleic acids…eg. ACG)

ALSO…

- May code for start = **initiator codon** (starts protein synthesis)

  (AUG)
- May code for stop = **terminator codon** (stops protein synthesis)

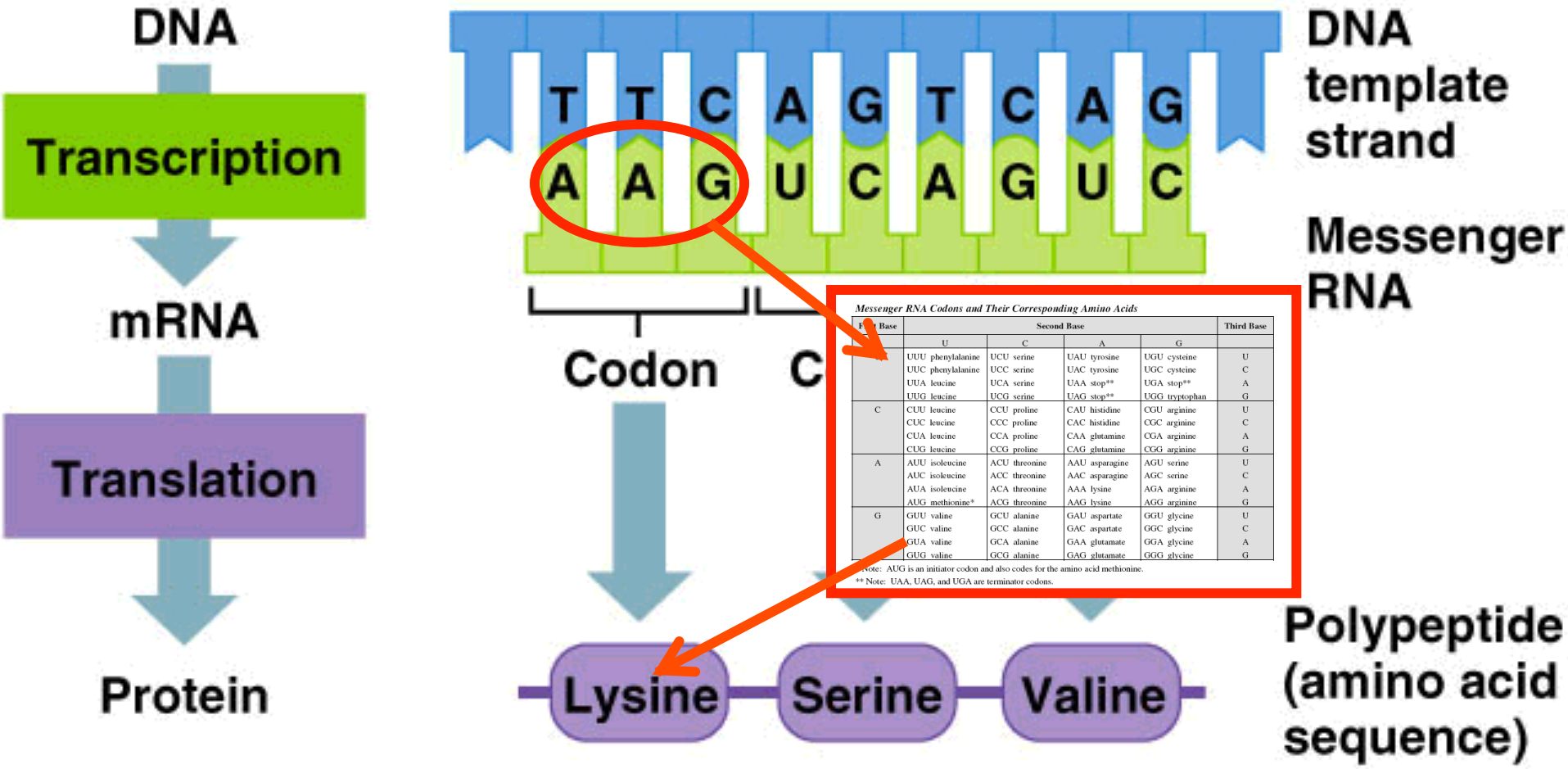
  (UAA UAG UGA)

- AUG is an **initiator codon** but also codes for the amino acid **methionine if in the MIDDLE of the protein being made**

Data table of mRNA codons is supplied in diploma!!

Code must be transcribed then translated

From DNA to RNA protein



Messenger RNA Codons and Their Corresponding Amino Acids

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop**	UGA stop**	A
	UUG leucine	UCG serine	UAG stop**	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG methionine*	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

* Note: AUG is an initiator codon and also codes for the amino acid methionine.
** Note: UAA, UAG, and UGA are terminator codons.

DON'T CONFUSE WITH DNA SEQUENCE!!

Messenger RNA Codons and Their Corresponding Amino Acids

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop**	UGA stop**	A
	UUG leucine	UCG serine	UAG stop**	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG methionine*	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

* Note: AUG is an initiator codon and also codes for the amino acid methionine.

** Note: UAA, UAG, and UGA are terminator codons.

An Example:

DNA non-coding	ATG GGC CGT AGC TAT CGT TAG
DNA coding strand	TAC CCG GCA TCG ATA GCA ATC
mRNA	AUG GGC CGU AGC UAU CGU UAG
Amino acids	start gly arg ser tyr arg stop

Transcription animation- narrated
http://www.youtube.com/watch?v=D5vH4Q_tAkY&feature=related

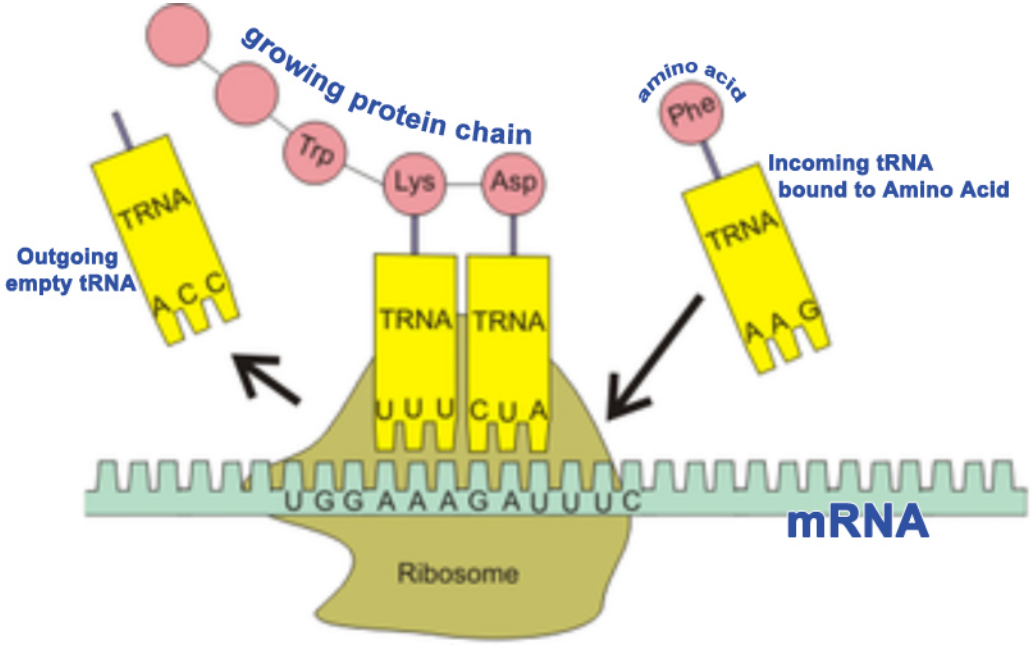

I wish I was adenine
then I could pair with U

Translation

- Occurs in the cytoplasm
- mRNA arrives at a ribosome
- This is where amino acids are assembled with the help of **tRNA** molecules
- **tRNA** brings the correct amino acid to the ribosome based on:

Complimentary base pair rules

Ex. A attracts U



- Since there are 20 amino acids , there are **20 different tRNAs**

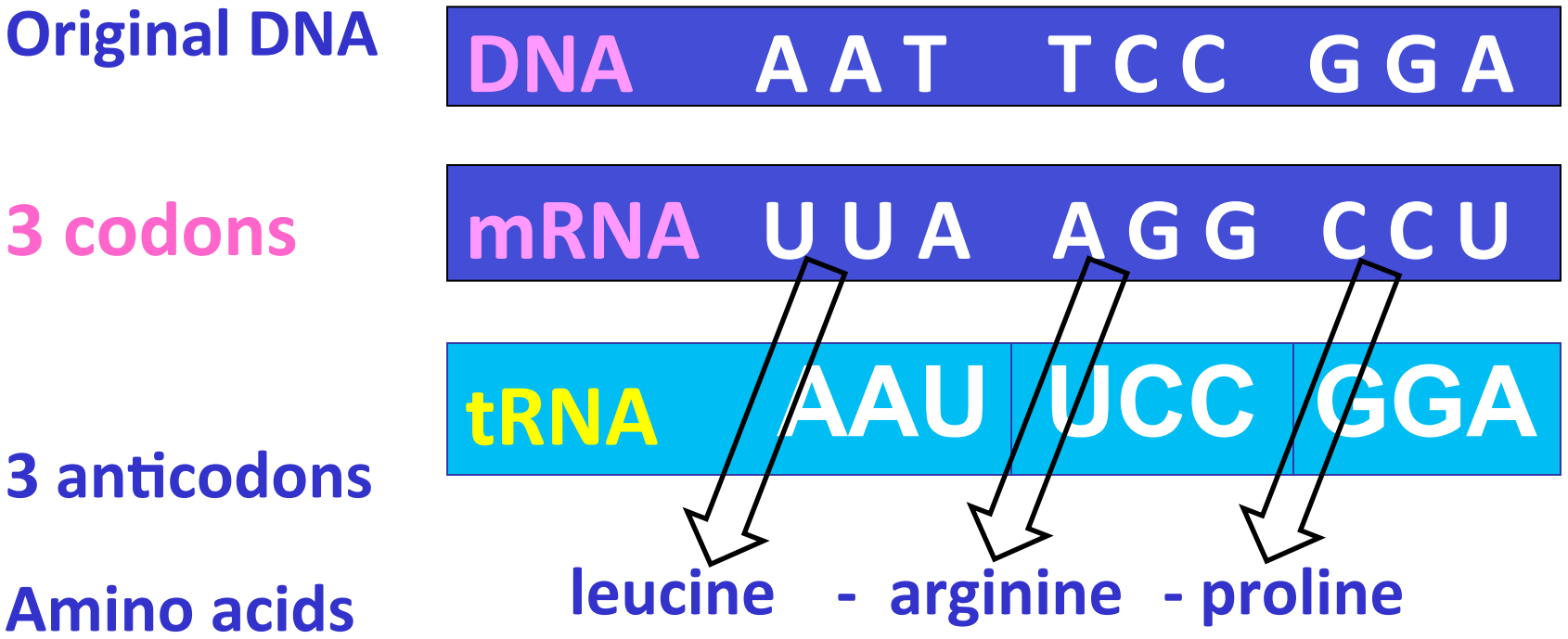
Translation Animation

Translation

- HOW DOES tRNA KNOW WHICH AMINO ACID TO BRING?

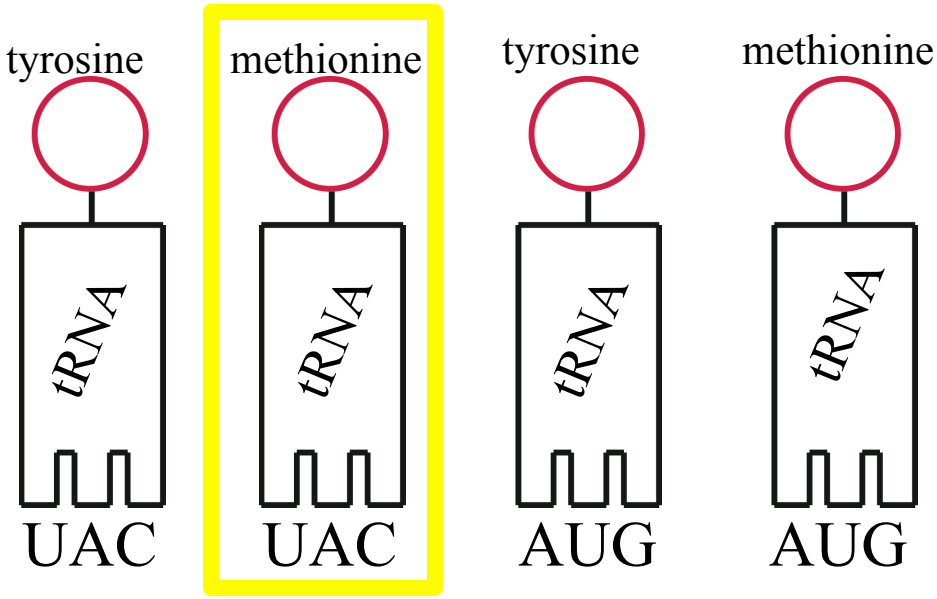
tRNA brings the correct amino acid to the ribosome when its **anticodon** matches the **mRNA codon.**

IMPORTANT: The amino acid required and brought in on the tRNA is determined by the codon on the mRNA(found on chart) and NOT THE ANTI-CODON



Example question.

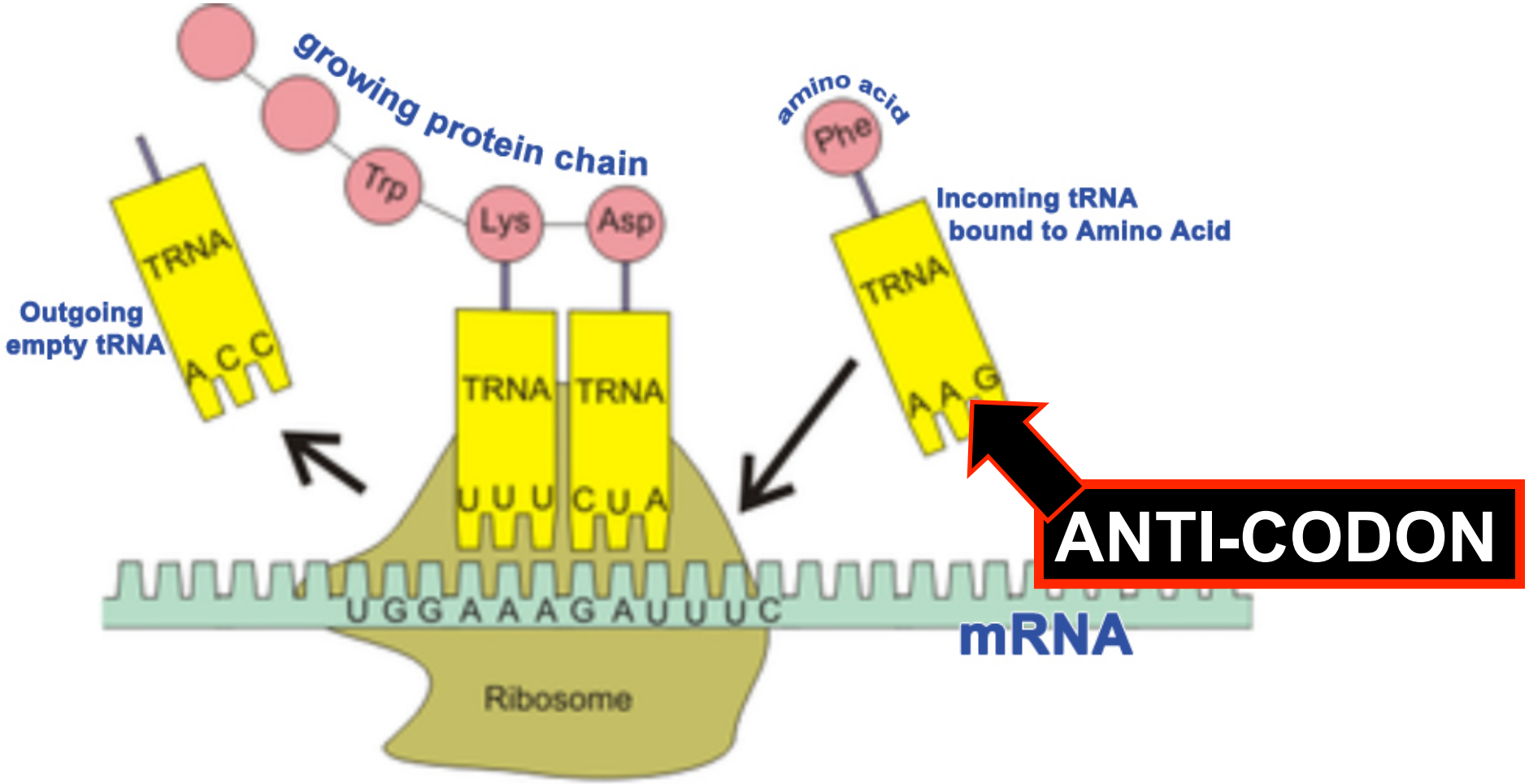
tRNA has an anti-codon that is UAC. Which amino acid will be used?



Because…

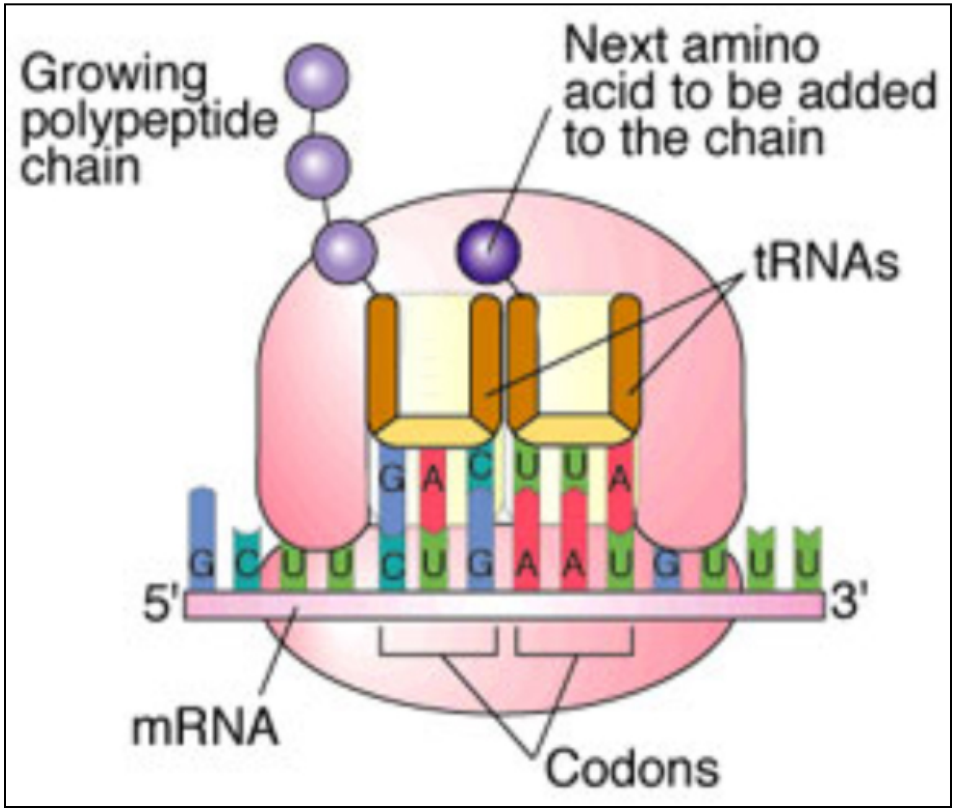
UAC is the anti-codon that is on the tRNA above but its complementary base pairing (on mRNA) is AUG which is used with the mRNA codon chart to determine that the amino acid used is methionine

Translation



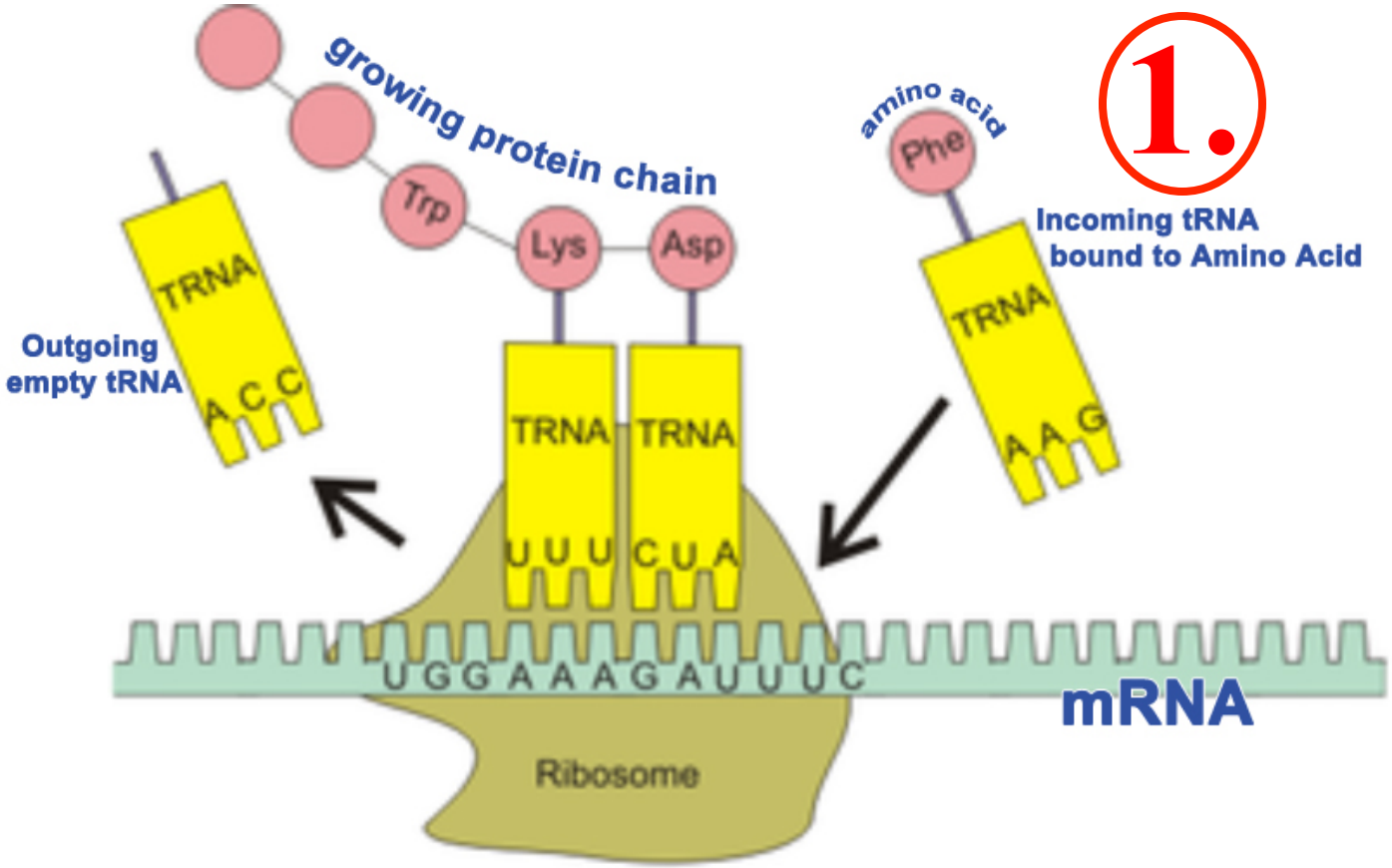
Translation:

- **mRNA** from the nucleus associates with a ribosome.
- **Ribosomes** are made up of rRNA and other proteins
- The ribosome acts like a scaffold, holding the mRNA in position while the **protein** is being built



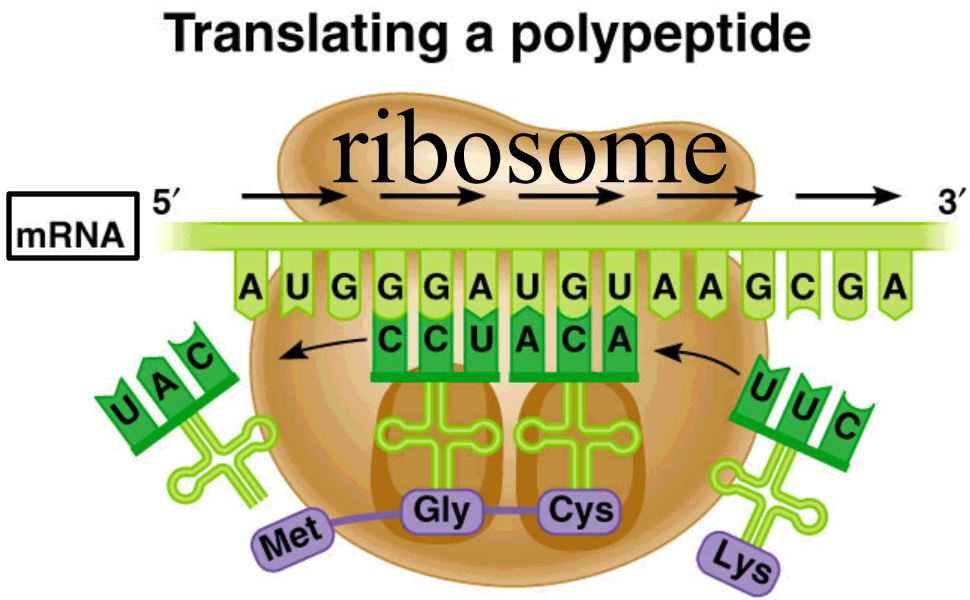
Translation Step 1

1. **tRNA, that has a matching anti-codon to the mRNA codon, picks up needed amino acid and joins with mRNA**



Translation Step 2

2. The ribosome moves down the mRNA and another tRNA brings the next amino acid.

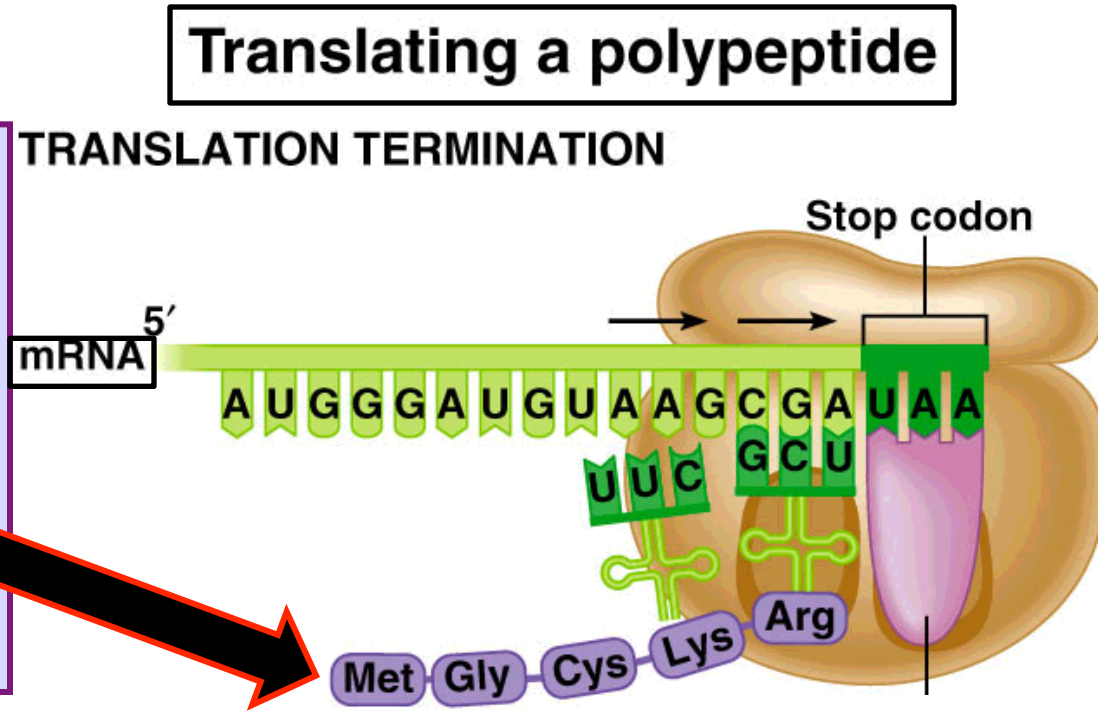


B

Adjacent amino acids are held together by peptide bonds.

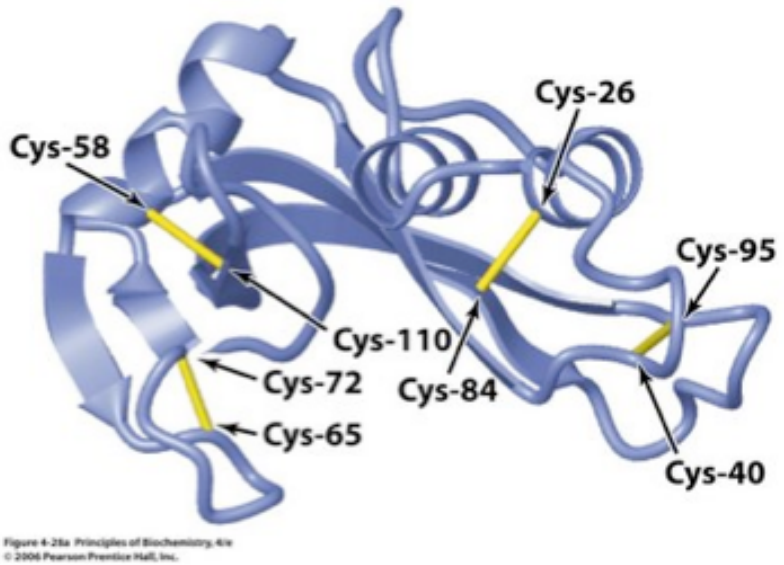
Translation Step 3

3. When mRNA codon reads "stop" (either UAG, UAA, or UGA), the polypeptide (amino acid chain) is released.

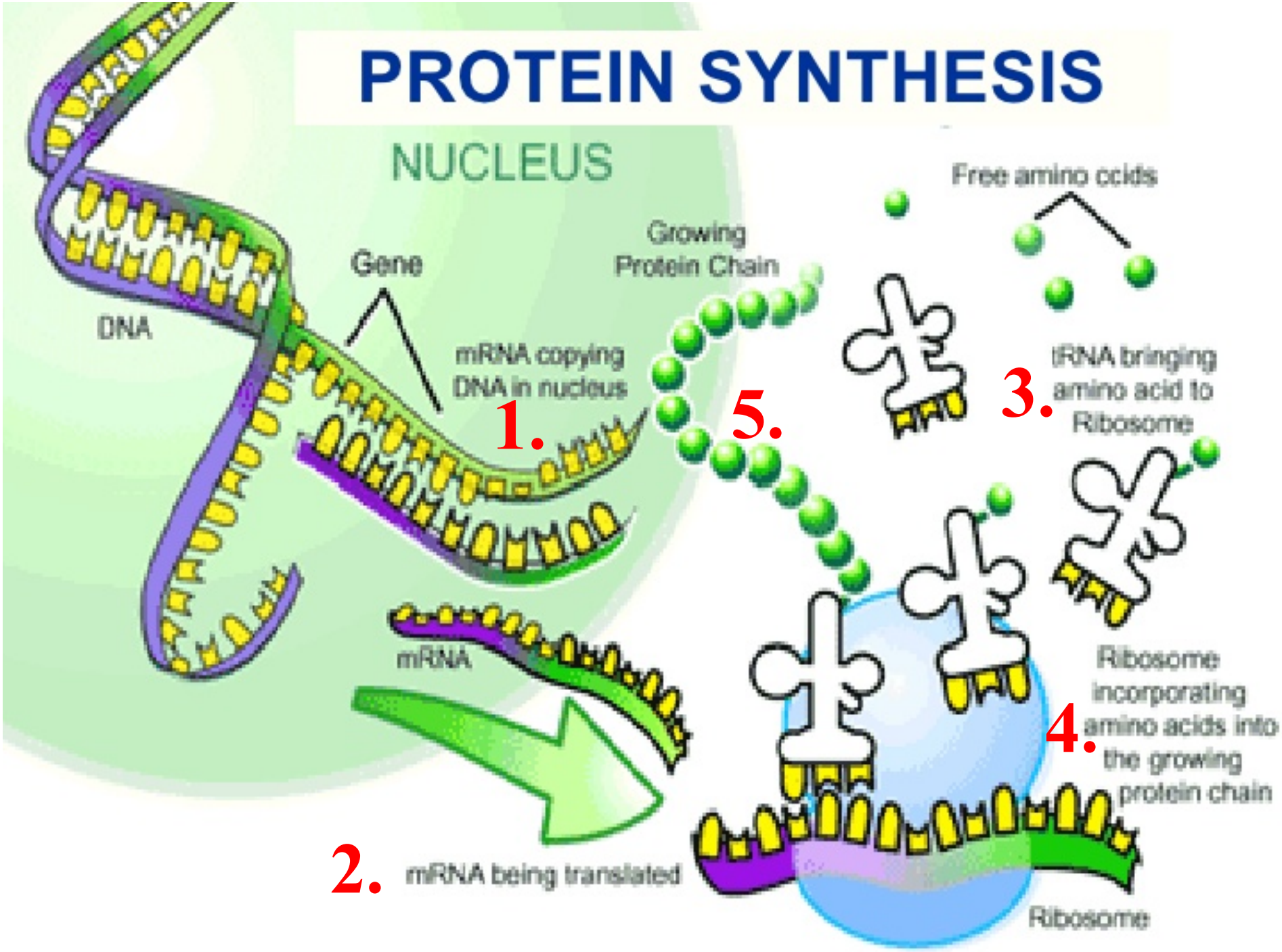


Protein Synthesis-THE FINAL RESULT

Depending on how the amino acids are assembled, they fold and take on different 3-D shapes



The shape of a protein is essential to its function


PROTEIN SYNTHESIS
NUCLEUS
DNA
Gene
mRNA copying DNA in nucleus
1.
mRNA
2.
mRNA being translated
Growing Protein Chain
Free amino acids
5.
3.
tRNA bringing amino acid to Ribosome
Ribosome incorporating amino acids into the growing protein chain
4.
Ribosome

Protein Synthesis

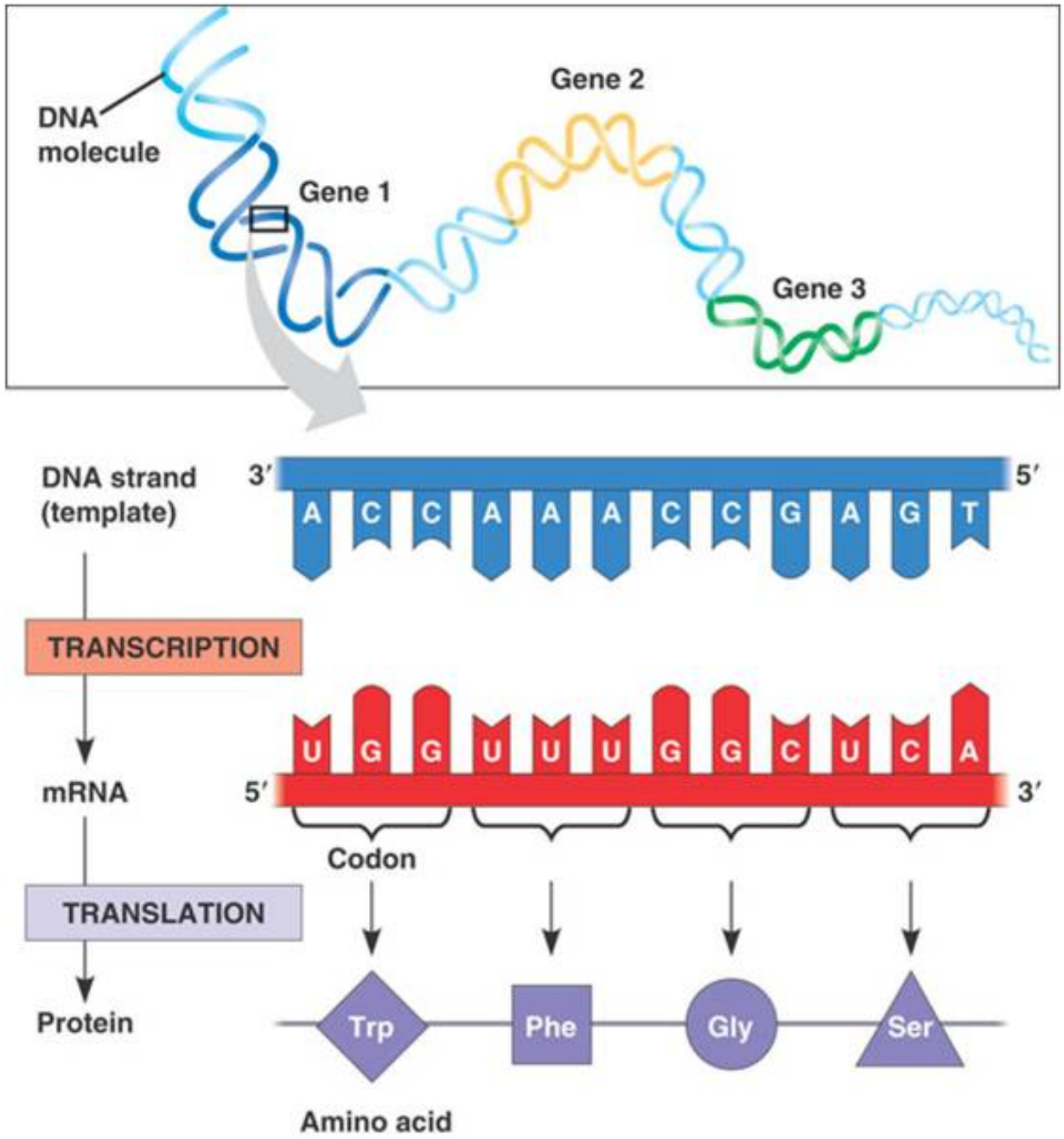
Transcription

- Location: **nucleus**
- DNA (a gene) is used to code for mRNA
- One gene = one protein
- "T" is replaced with "**U**"

Translation

- Location: **cytoplasm and ribosomes**
- mRNA is read
- tRNA transfers amino acids
- amino acids are linked by **peptide bonds**

WATCH - Bozeman-Transcription and Translation



NO WATCH-Video: Protein Synthesis on youtube

NO WATCH - From RNA to Protein Synthesis

DNA song

Build Your Own Protein

http://learn.genetics.utah.edu/content/molecules/transcribe/

Extra:

Crash Course: Transcription & Translation

skip 5:13-7:28 - watch till 11:00

Extra:

Bozeman DNA,RNA and Protein Synthesis

1	C									DNA strand 1 (non-coding)
2							A	G	G	DNA strand 2 (coding)
3		C	A				U			mRNA codons
4				U	G	G				tRNA anticodons
5										amino acids

Can you go back and forth? Given an mRNA codon, you should be able to determine the nucleotide sequence on the DNA coding strand, tRNA anticodons and the amino acids!

1	C	C	A	A	C	C	T	C	C	DNA strand 1 (anti-sense)
2	G	G	T	T	G	G	A	G	G	DNA strand 2 (sense)
3	C	C	A	A	C	C	U	C	C	mRNA codons
4	G	G	U	U	G	G	A	G	G	tRNA anticodons
5	PROLINE			THREONINE			SERINE			amino acids

Can you go back and forth? Given an mRNA codon, you should be able to determine the nucleotide sequence on the DNA coding strand, tRNA anticodons and the amino acids!

Review Questions

- What is the mRNA codon for the DNA triplet AAT = **UUA**
- What is the DNA triplet for the mRNA codon CCG = **GGC**
- What is the tRNA anticodon for the DNA triplet GCA = **CGU** (mRNA) = **GCA** (tRNA)
- What is the mRNA codon for the tRNA GAU = **CUA**
- What is the tRNA anticodon for the mRNA codon UUA = **AAU**
- What is the DNA triplet for the anticodon CUA = **GAU** (mRNA) = **CTA** (DNA)
- What is the codon for the anticodon UAG = **AUC**
- What is the anticodon for the DNA triplet CTA = **GAU** (mRNA) = **CUA** (tRNA)

Make your own protein!

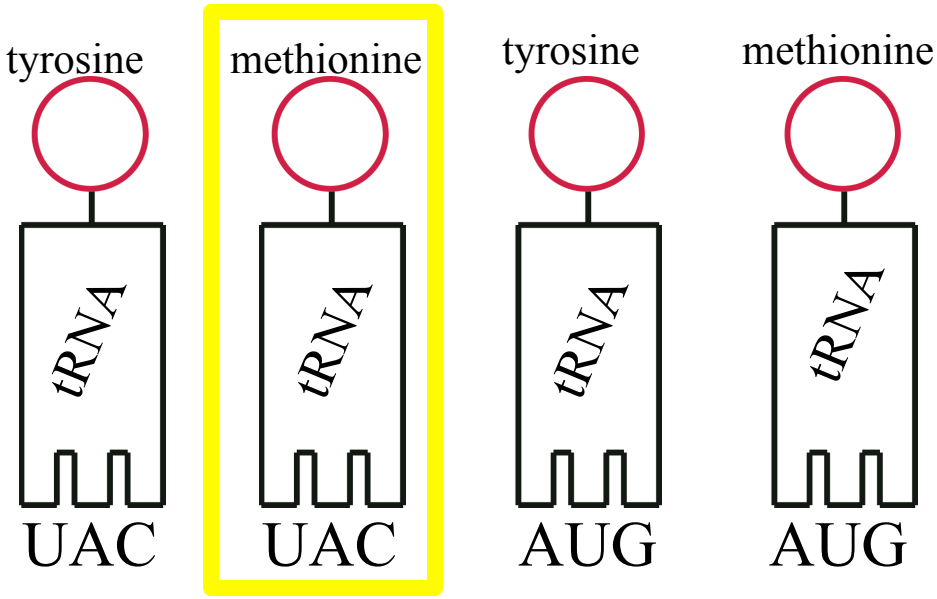
Great Review Videos

Transcription

- http://www.youtube.com/watch?v=D5vH4Q_tAkY&feature=related

Example question.

tRNA has an anti-codon that is UAC. Which amino acid will be used?



Because…

UAC is the anti-codon that is on the tRNA above but its complementary base pairing (on mRNA) is AUG which is used with the mRNA codon chart to determine that the amino acid used is methionine

The hemoglobin molecule contains iron. A portion of the DNA template that codes for the hemoglobin molecule is shown below.

CAT GCC ATA GAG

The anticodon of the tRNA molecule that transports the first amino acid coded by this portion of the DNA molecule is

A. CAU
B. CUA
C. GAU
D. GUA

DNA: CAT
mRNA: GUA
tRNA: CAU

A DNA nucleotide triplet that codes for the amino acid glutamine is

A. GAC
B. GTC
C. CTT
D. CTC

On mRNA codon chart glutamine = CAA or CAG

mRNA: CAA CAG
DNA: GTT GTC

The mRNA nucleotides that are transcribed from the DNA trinucleotide CTG contain phosphate,

A. ribose, and the bases guanine, adenine, and cytosine
B. ribose, and the bases cytosine, thymine, and guanine
C. deoxyribose, and the bases guanine, adenine, and cytosine
D. deoxyribose, and the bases cytosine, thymine, and guanine