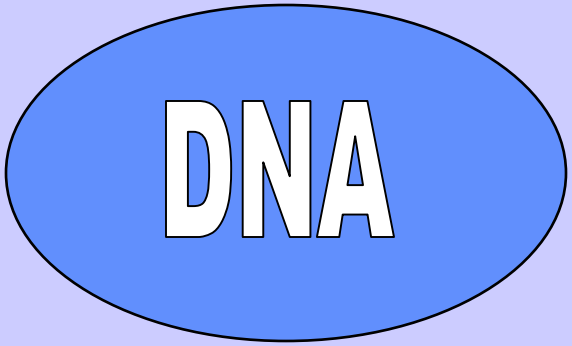
DNA

Introduction

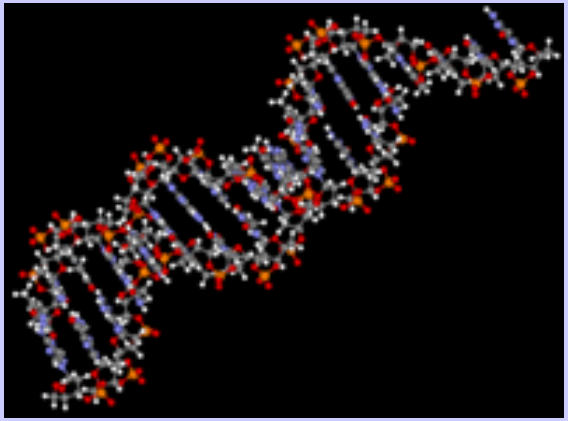
Do you think DNA is important?

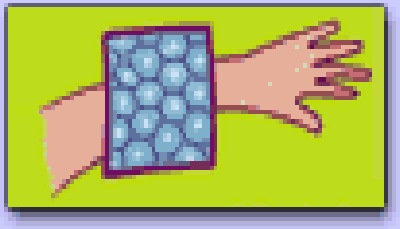
- T.V shows
- Movies
- Biotech Films
- News
- Cloning
- Genetic Engineering


DNA

DNA and Genes

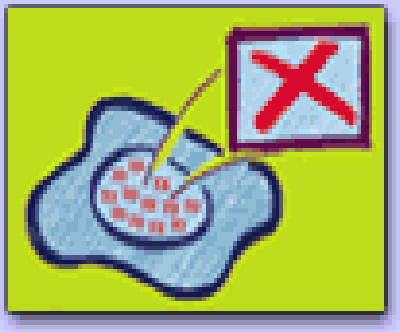
- **At the most basic level DNA is a set of instructions for protein construction.**
  - **Structural**
  - **Enzymes**
  - **Hormones**



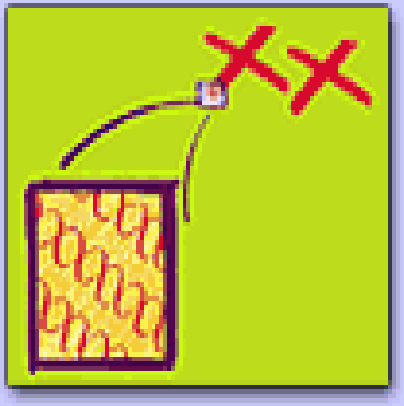


Every living thing is made of **cells.**

Most plant and animal cells have a **nucleus.** The nucleus tells the cell what to do.



Inside the nucleus are **chromosomes.**



Chromosomes are made of long strands of tightly coiled DNA. (If you stretched out the DNA from a human cell, it would be about six feet long!)

DNA

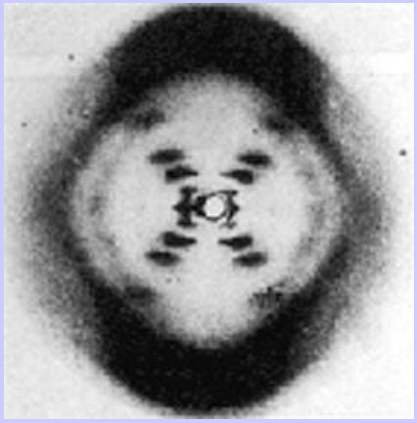
- Deoxyribonucleic acid
- Every living thing has DNA
  - That means that you have something in common with a zebra, a tree, a mushroom and a beetle!!!!

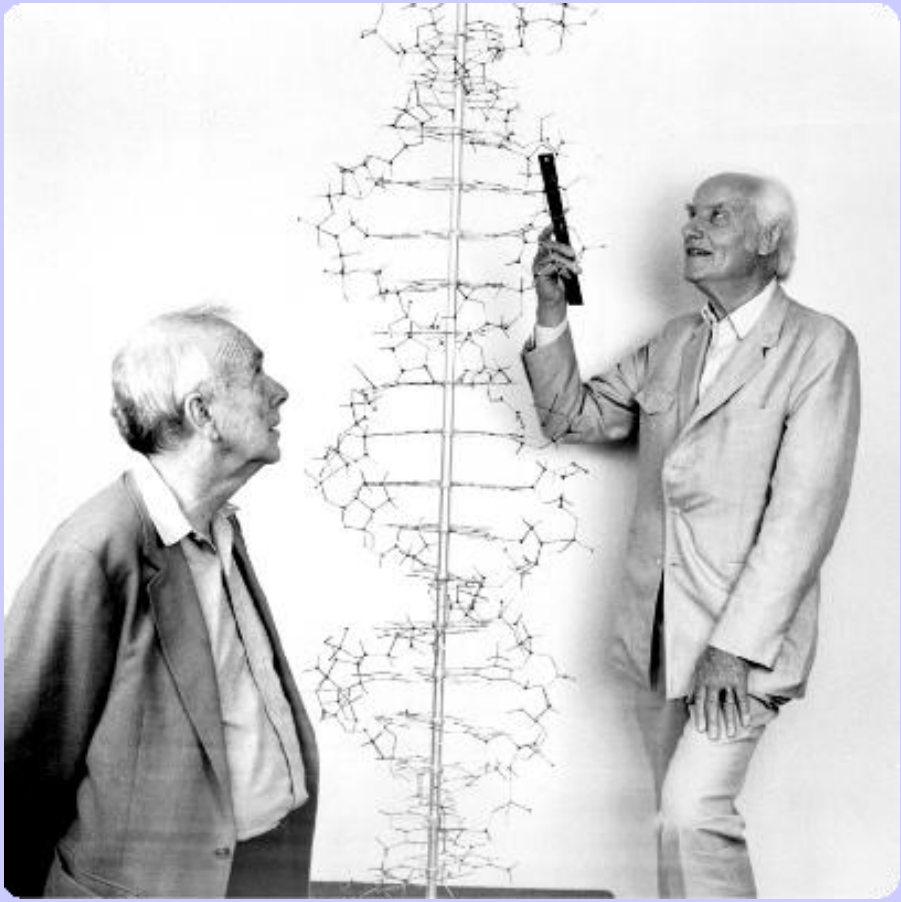
What do you need to know?

- Structure of DNA
- How DNA replicates (reproduces)?
- How DNA transcribes RNA?
- How Ribosomes use the RNA to correctly assemble proteins?

Watson and Crick

- Nobel Peace Prize
- The Double Helix, 1953
- Outlined the Structure of the DNA
- Discovered the “locking” of bases





DNA: video
play in – VLC media player
17:06-23:00

DNA as Genetic Material

Macromolecules

1. Carbohydrate
2. Lipids
3. Proteins
4. Nucleic Acids (DNA an d RNA)

-- Nucleic Acids are made up of nucleotides

-- Nucleotides = monomers; nucleic acid = polymers

--So, DNA and RNA are nucleic acids because they're made up of nucleotides

Deoxyribonucleic acid

Ribonucleic acid

DNA

- DNA contains genes, sequences of nucleotide bases
- These genes code for polypeptides (proteins)
- Proteins are used to build cells and do much of the work inside cells

Genes & Proteins

- Proteins are made of amino acids linked together by peptide bonds
- 20 different amino acids exist

Polypeptides

- Amino acid chains are called polypeptides

DNA Structure

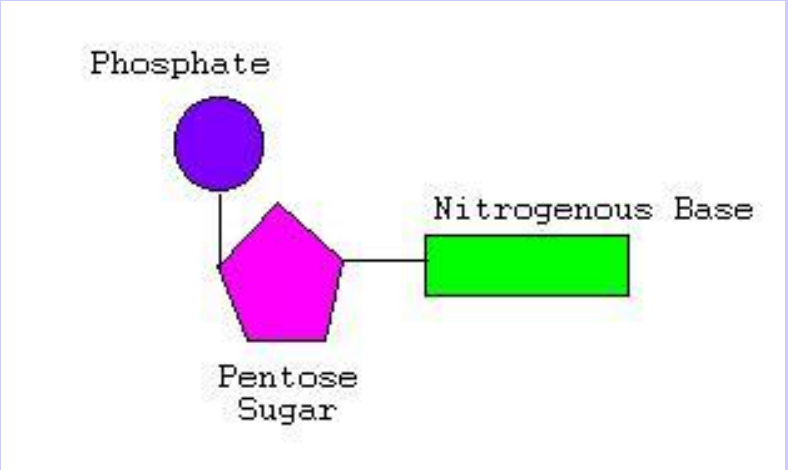
- DNA is a polymer
- Each nucleotide consists of:
  - 5 carbon sugar (deoxyribose)
  - Nitrogen containing base attached to the sugar
  - Phosphate group
- There are 4 different types of nucleotides found in DNA, differing only in the nitrogenous base

DNA Structure

- The 4 nucleotides are given one letter abbreviations as shorthard for the 4 bases
  - A is for adenine
  - G is for guanine
  - C is for cytosine
  - T is for thymine

Purine

Pyrimidine

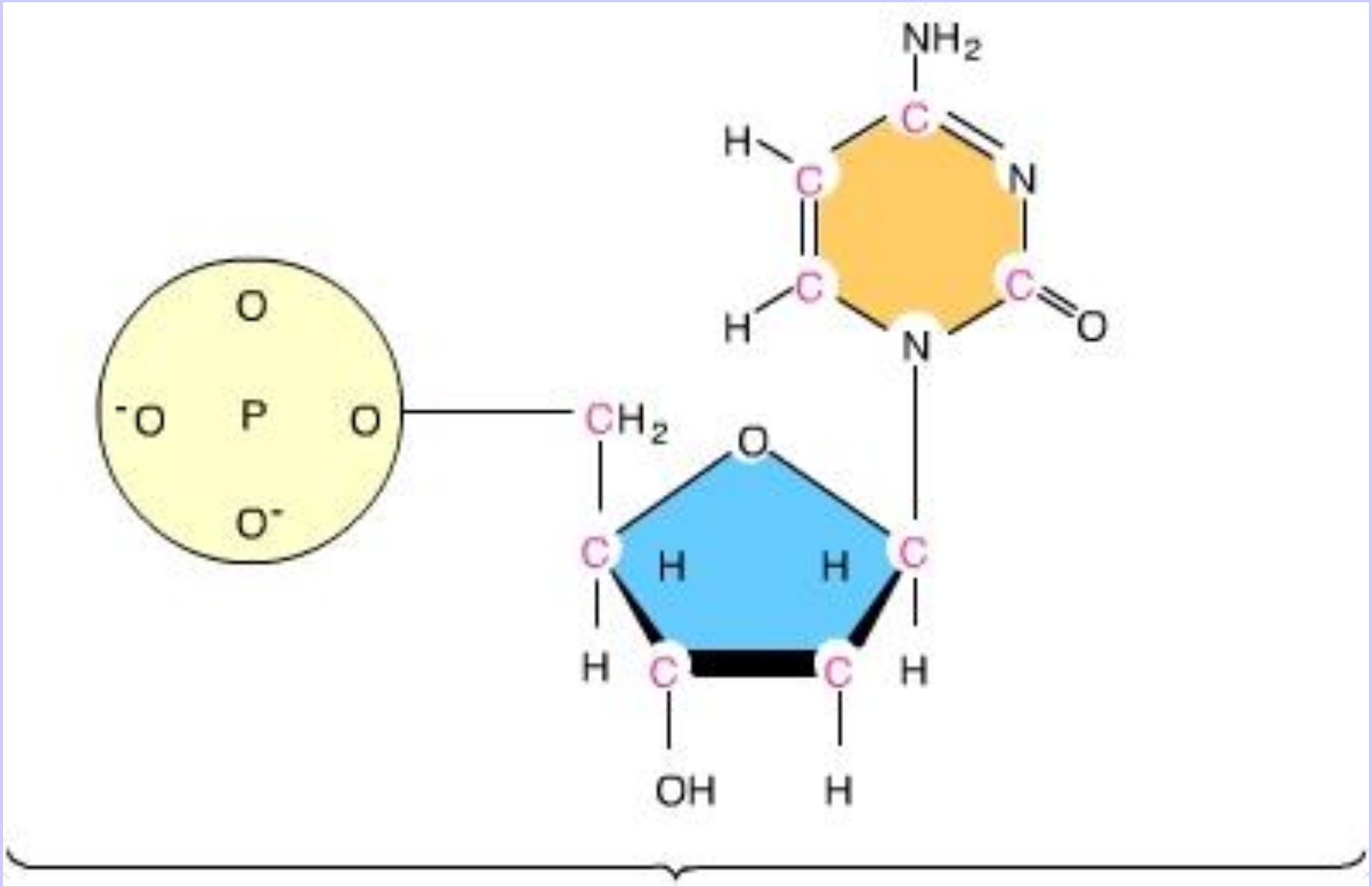


Deciphering DNA's structure.

of **purine** bases = # of **pyrimidine** bases

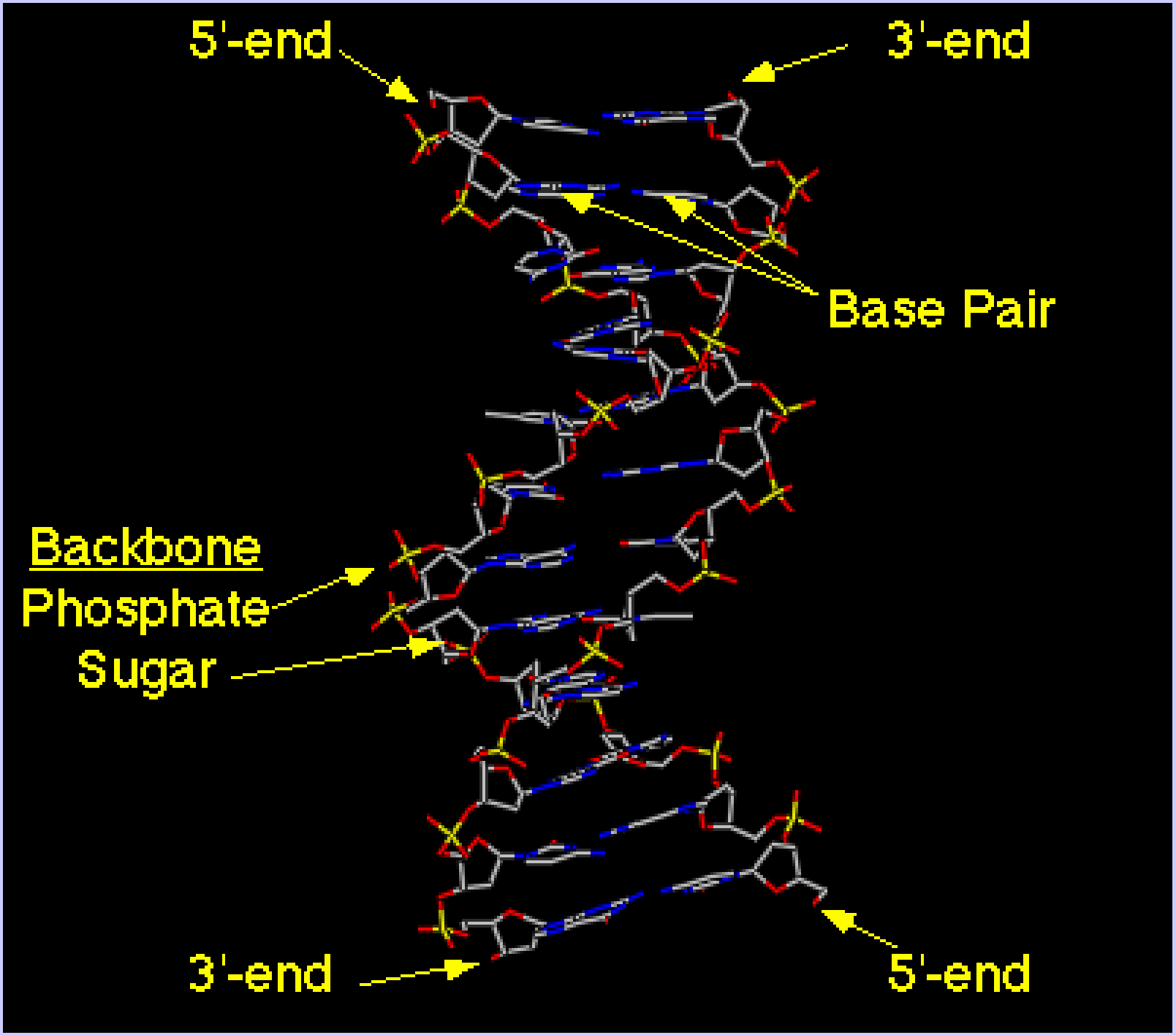
of **adenine** bases = # of _____ bases

of **guanine** bases = # of _____bases


NH2
C
H
C
N
C
C
O
H
N
O
-O
P
O
O-
CH2
O
C
H
H
C
H
C
C
H
OH
H

DNA Structure

- Sugar-phosphate backbone
- Hydrogen bonds → Hold DNA strands together
- Can only form between certain bases
  - A & T → 2 H-bonds
  - G & C → 3 H-bonds
- So, bases on one strand determines the bases on the other strand
- Paired bases = complementary base pairs
- DNA → Double helix; long zipper, twisted into a coil


5'-end
3'-end
Base Pair
Backbone
Phosphate
Sugar
3'-end
5'-end

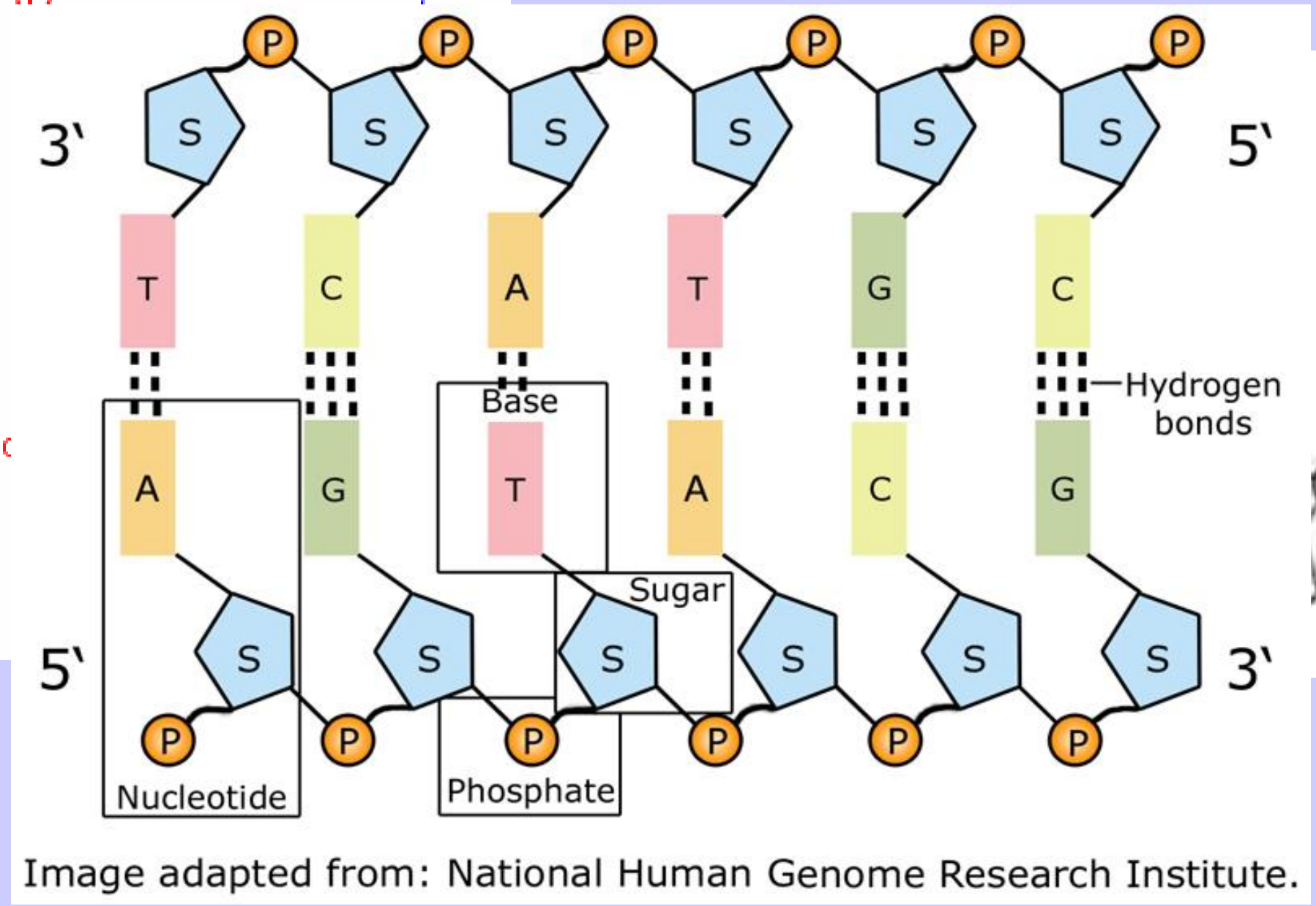
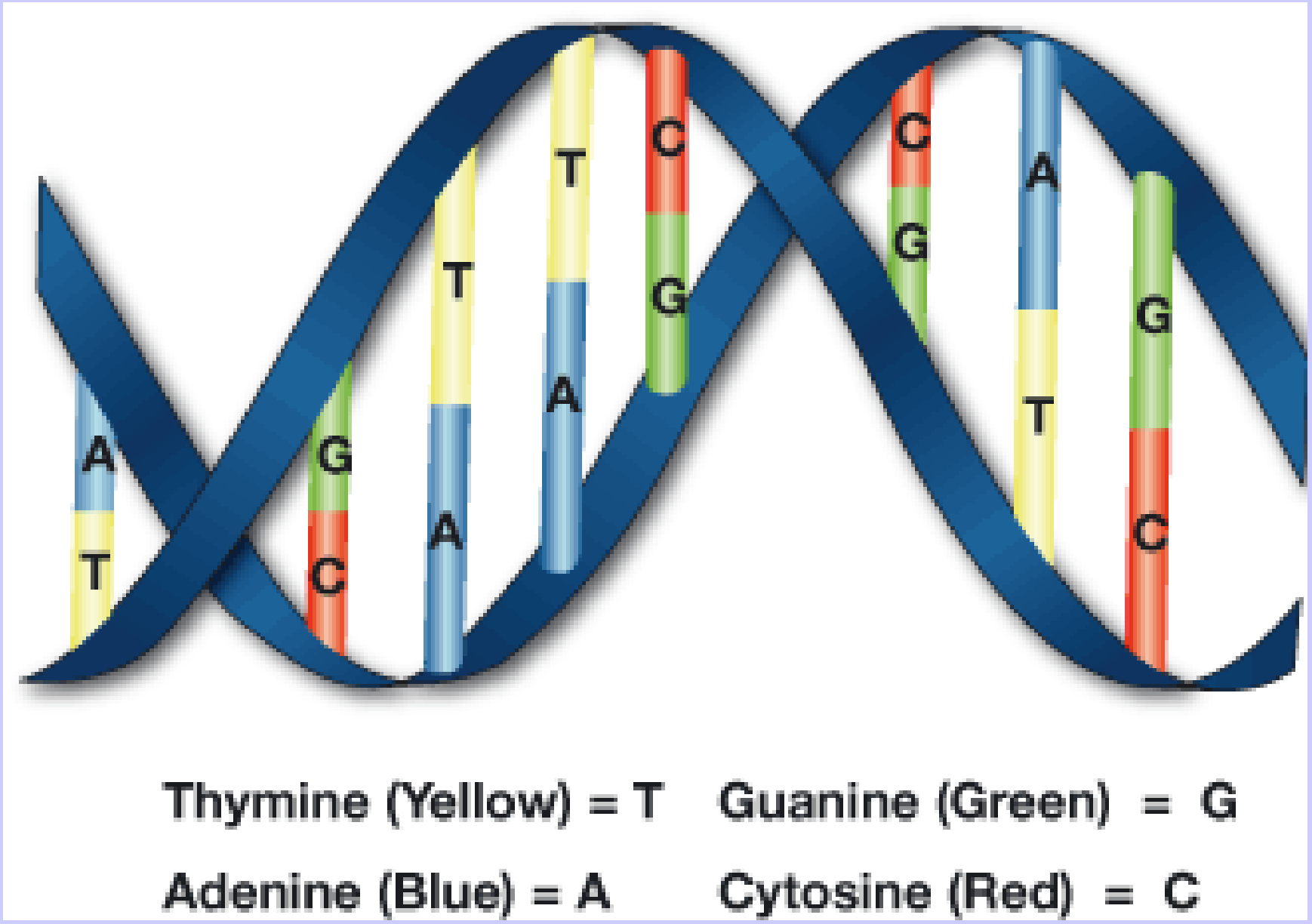


Image adapted from: National Human Genome Research Institute.



Thymine (Yellow) = T Guanine (Green) = G

Adenine (Blue) = A Cytosine (Red) = C

DNA: structure video
play in – VLC media player

DNA Begins the Process (review material)

- **DNA** is found inside the **nucleus**
- **Proteins**, however, are made in the **cytoplasm** of cells by organelles called **ribosomes**

Starting with DNA

- DNA 's code must be copied and taken to the cytoplasm
- In the cytoplasm, this code must be "read" so amino acids can be assembled to make polypeptides (proteins)
- This process is called PROTEIN SYNTHESIS

DNA REPLICATION

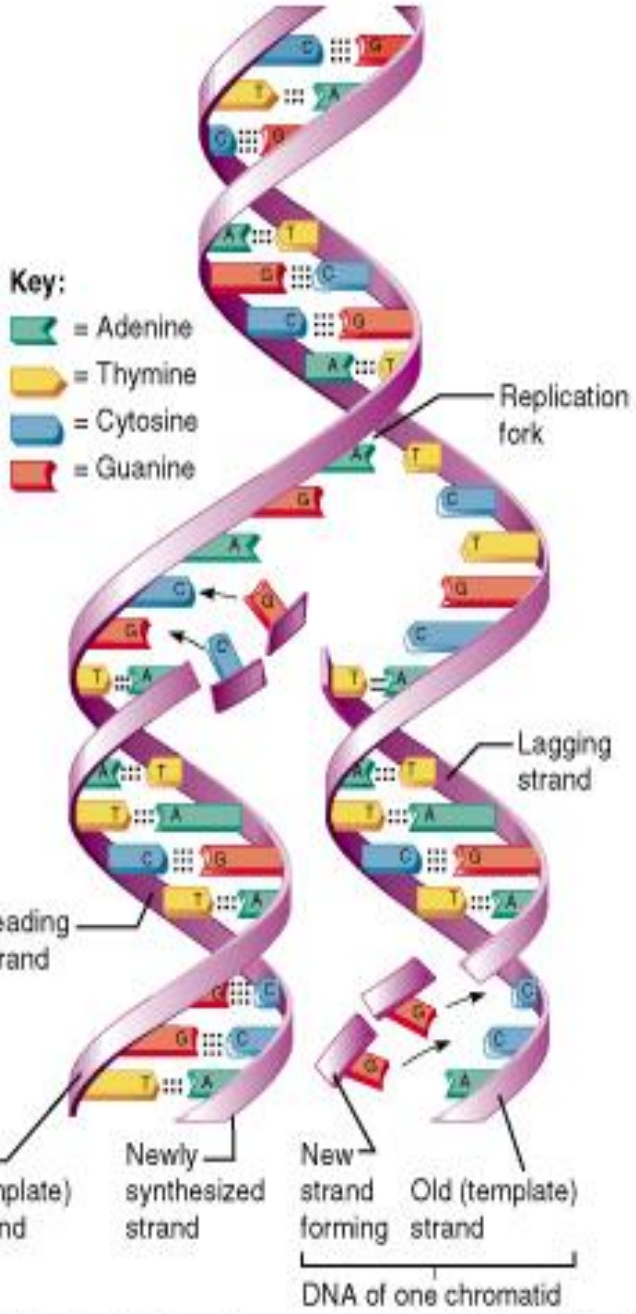
COSMOS video: DVD
(5minutes)

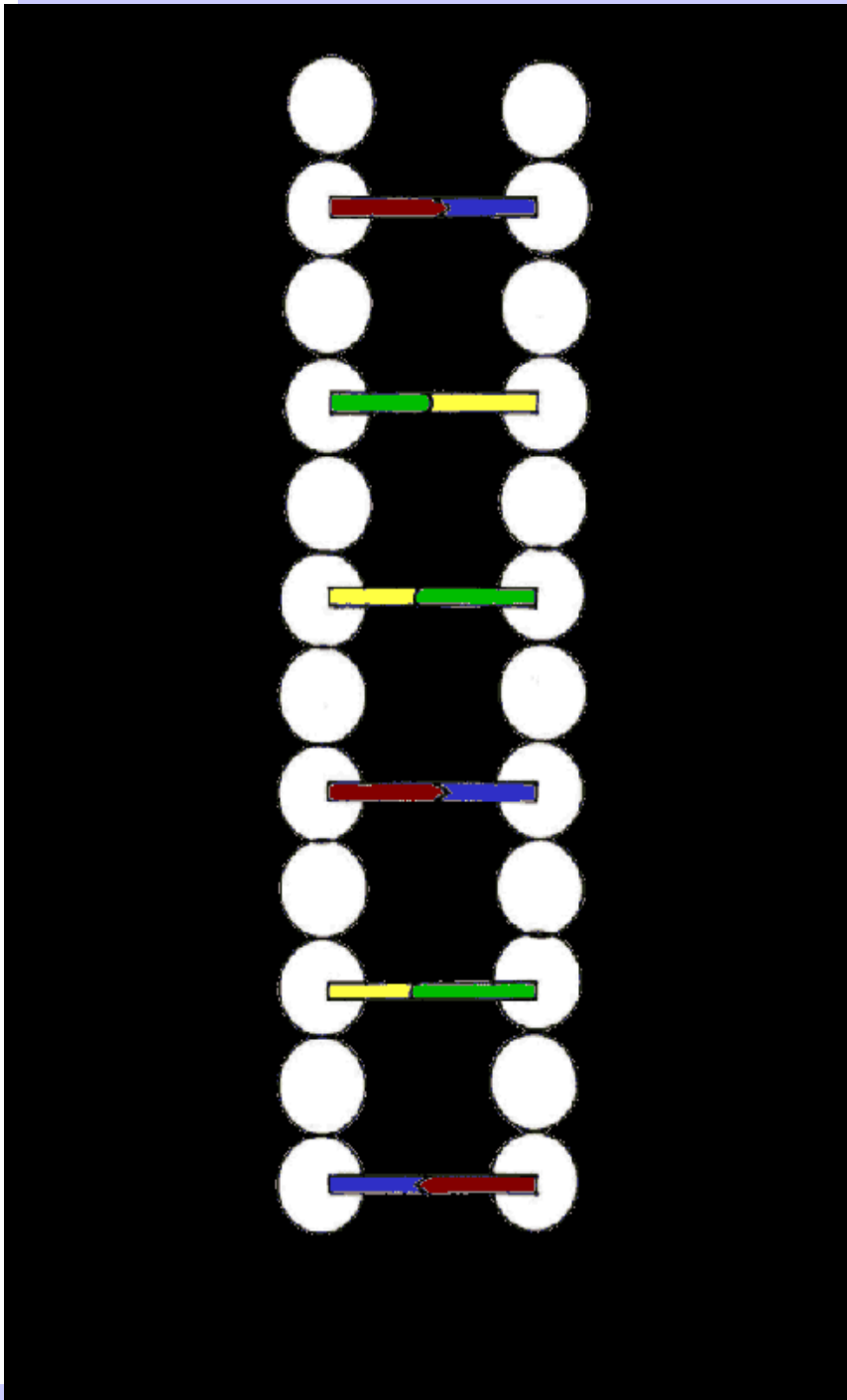
DNA Replication

- DNA Replication Website
- Produces 2 exact copies of DNA
- Occurs just prior to cell division

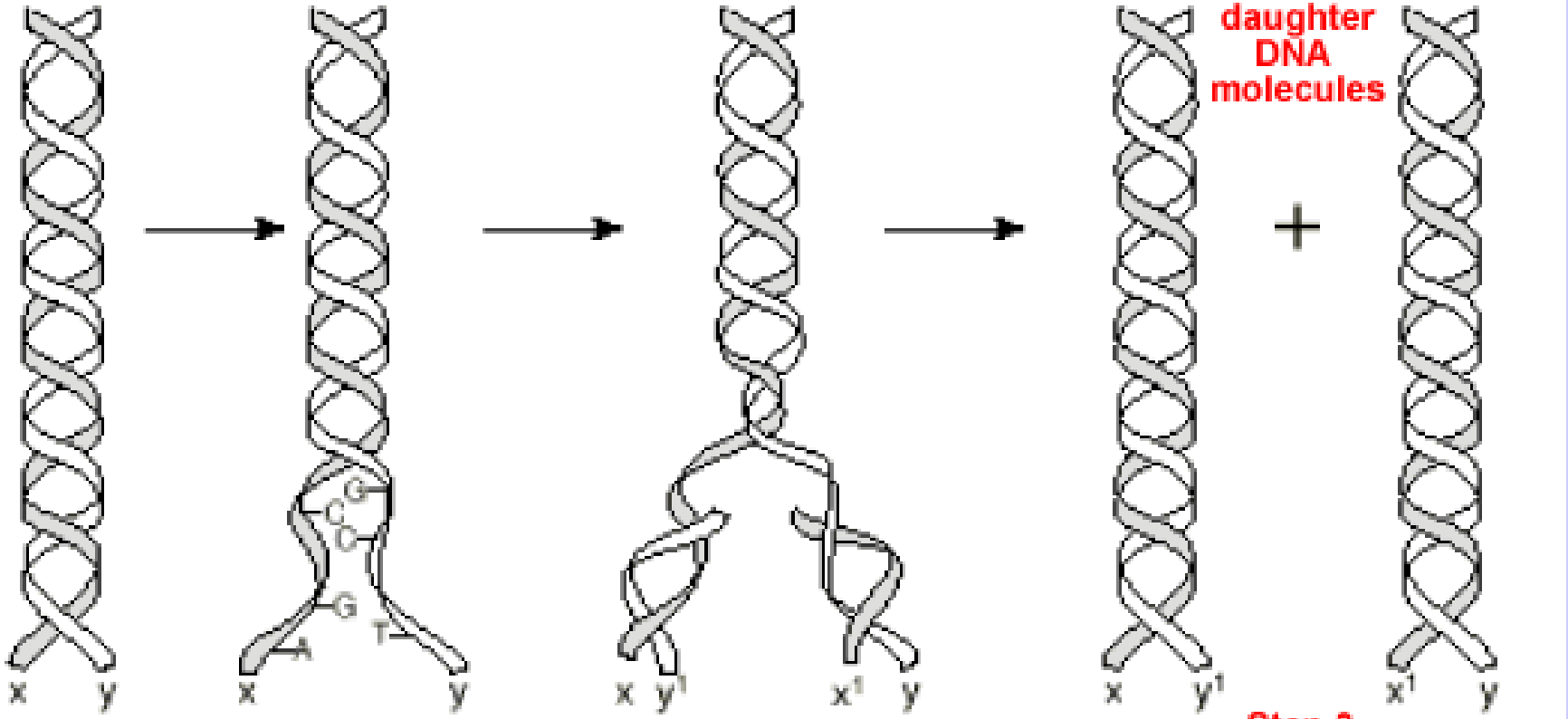
Steps of DNA Replication

- H bonds break between the two strands
- 2 strands of DNA molecules separate (enzyme)
- bases of free nucleotides in nucleus of cell fasten onto complementary bases on each exposed strand (enzymes to proofread)
- nucleotides join together making complete complementary strands
- 2 double stranded molecules of DNA *exactly* like the original are made (each with one old strand & one new strand)
- Replication forks
    - replication begins at the same time at *many* different points along the DNA molecule
    - enzymes link small segments into one long strand
    - replication occurs quickly





DNA REPLICATION



Parent DNA

Step 1 Unzipping

Step 2 Complementary Base Pairing

Step 3 Sugar-Phosphate Backbone formed connecting nucleotides in the two new strands

Practice:
DNA REPLICATION

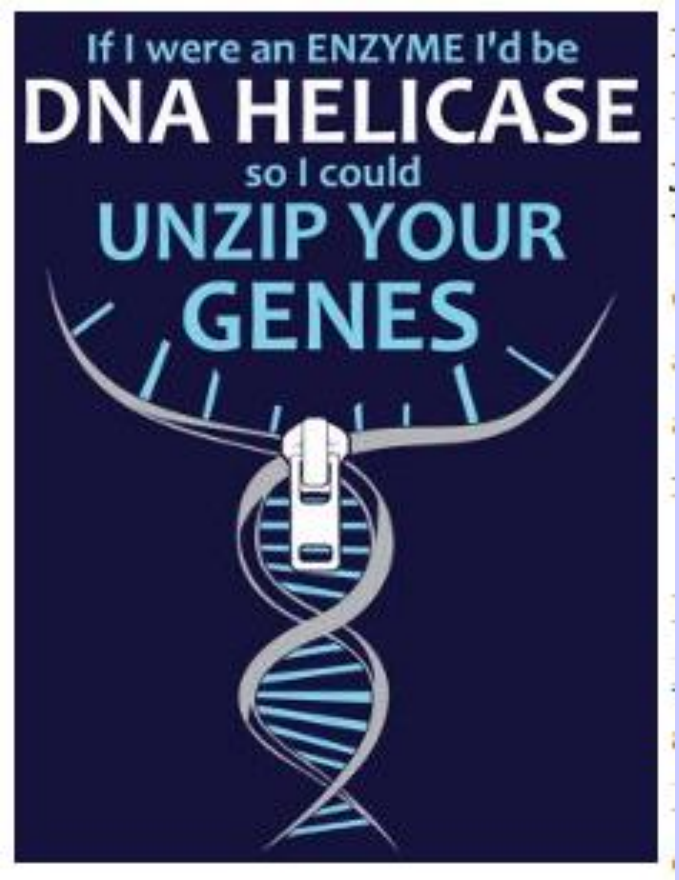
- 5’ CTG ACT CCT GAG GAG 3’
- 3’ 5’

Practice:
DNA REPLICATION

- 5’ CTG ACT CCT GAG GAG 3’
- 3’ GAC TGA GGA CTC CTC 5’

DNA Replication

- http://www.youtube.com/watch?v=hyI2mYfbbxk



DNA: replication video play in – VLC media player

PROTEIN SYNTHESIS

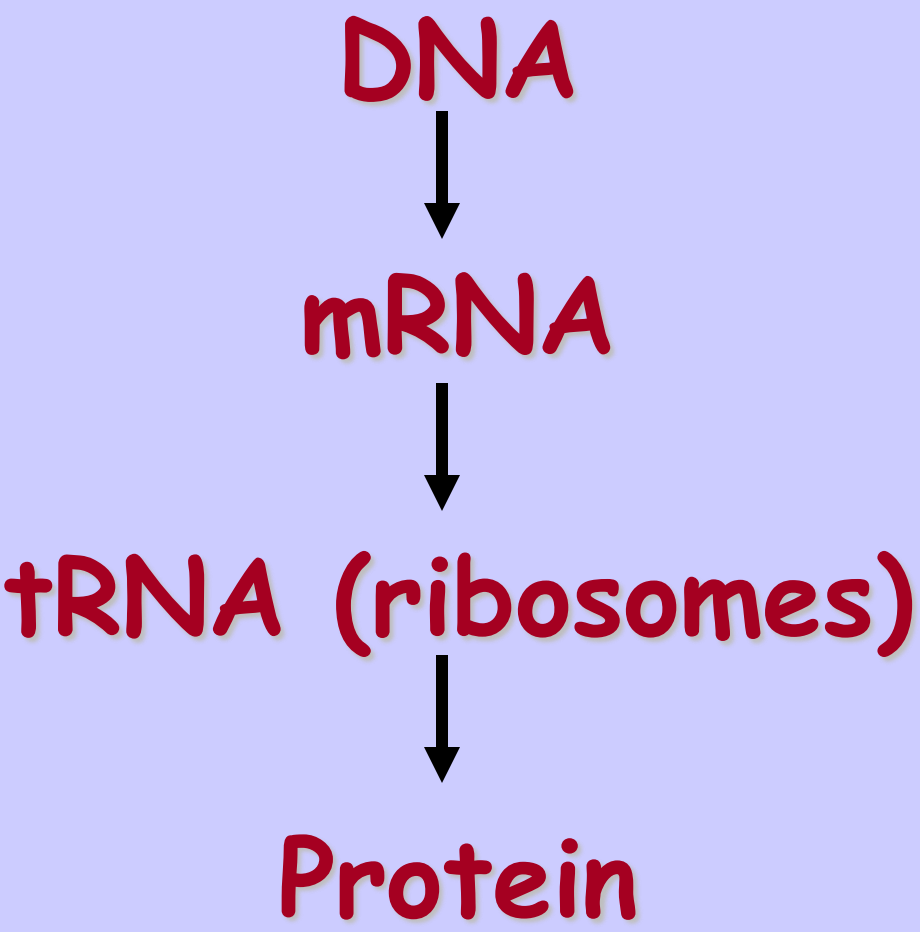
Protein Synthesis

- The production (synthesis) of **proteins**.
- **3 phases**:

1. **Transcription**
2. **RNA processing**
3. **Translation**

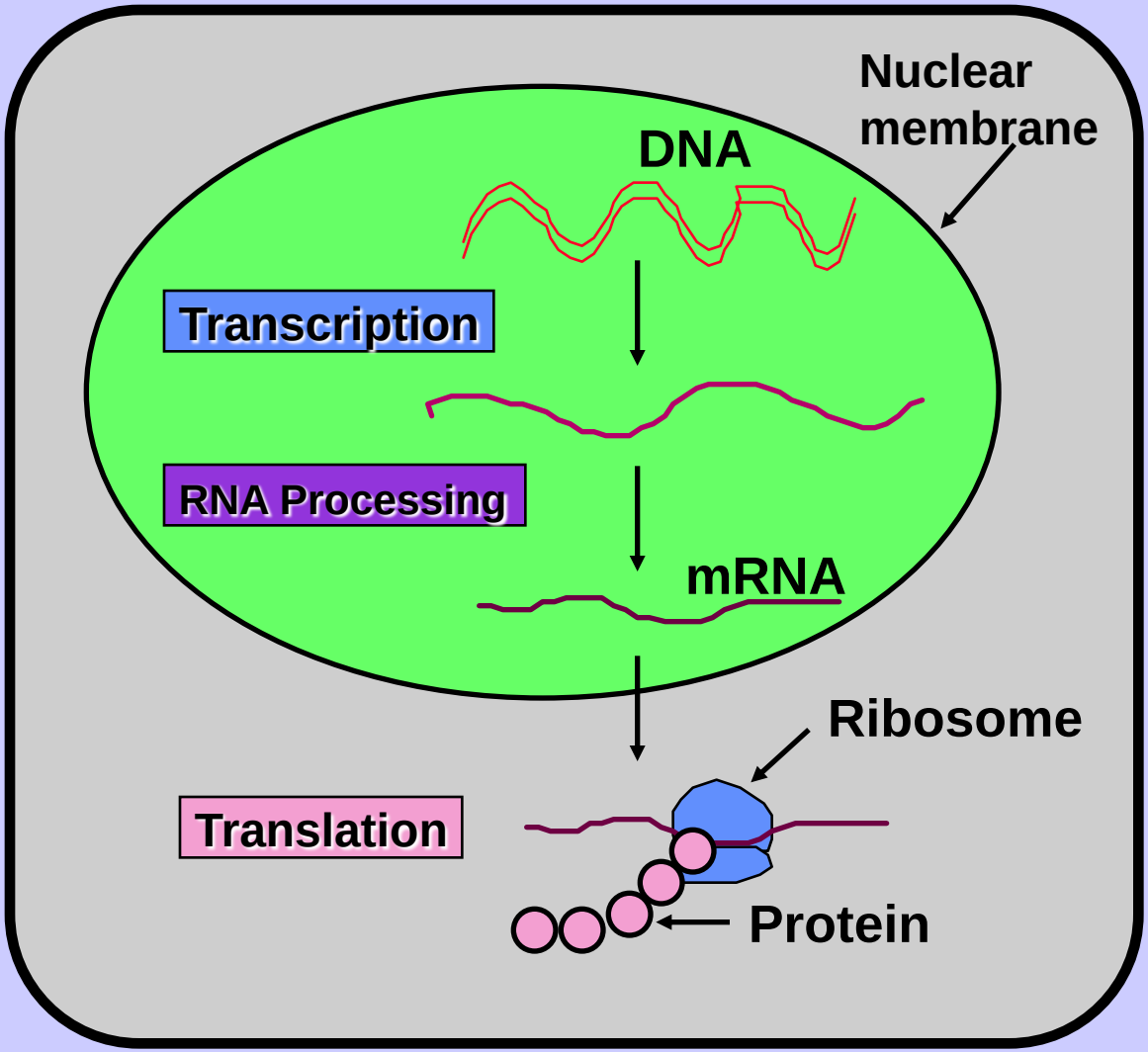
- **Remember: DNA → RNA → Protein**

Pathway to Making a Protein



DNA → RNA → Protein

Eukaryotic Cell



Question:

- How does **RNA (ribonucleic acid)** differ from **DNA (deoxyribonucleic acid)**?

RNA differs from **DNA**

1. **RNA** has a **sugar ribose**
   DNA has a **sugar deoxyribose**

2. **RNA** contains **uracil (U)**
   DNA has **thymine (T)**

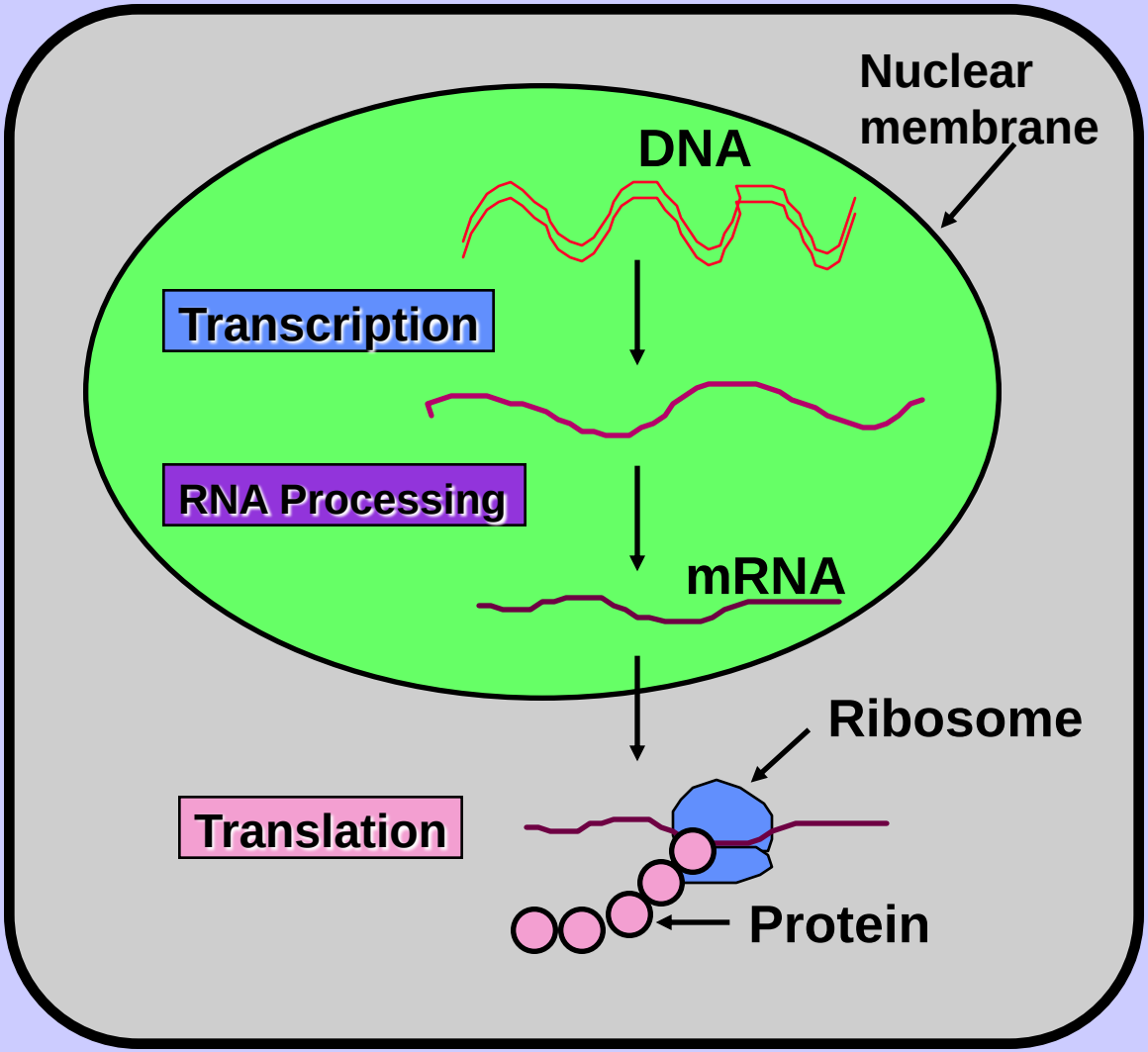
3. **RNA** molecule is **single-stranded**
   DNA is **double-stranded**

4. **RNA** molecule leaves the **nucleus**
   DNA stays in the **nucleus**

5. **RNA** is like a **page/recipe**
   DNA is like the **whole book**

1. Transcription

Eukaryotic Cell



1. Transcription

- The transfer of information in the **nucleus** from a **DNA** molecule to an **RNA** molecule.
- Only **1** **DNA** strand serves as the **template**
- When complete, RNA molecule can be released to the ribosomes.

Transcription animation
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf

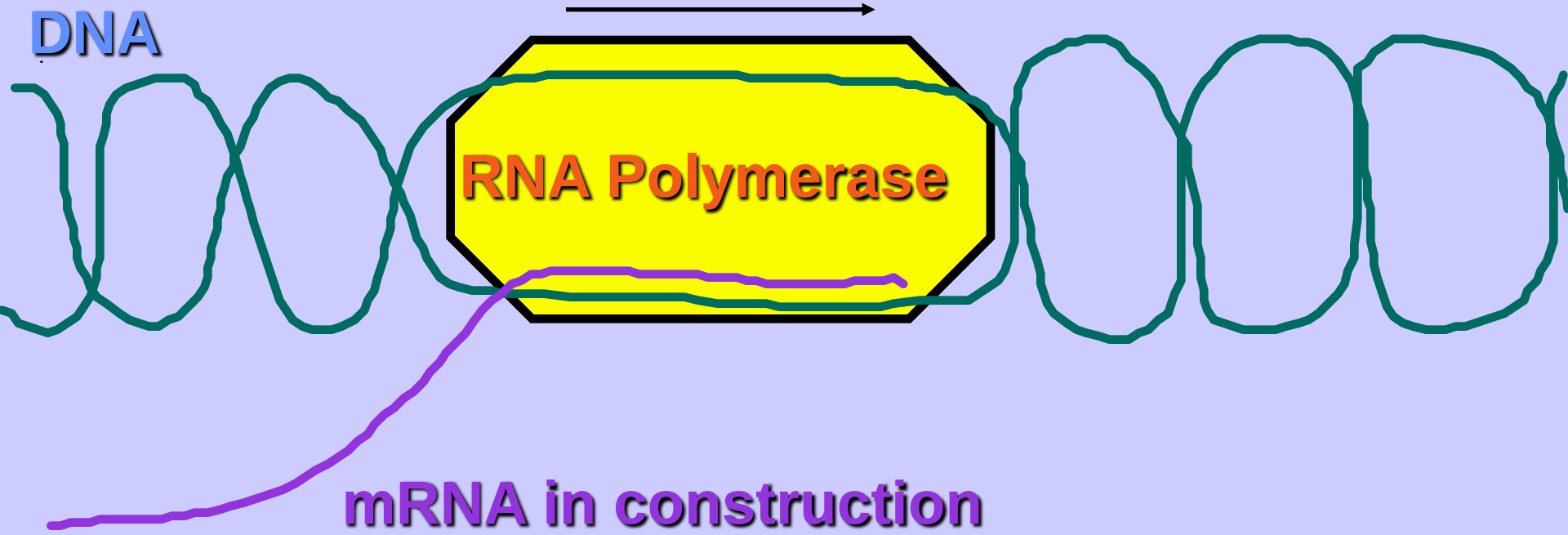
Question:

- What is the enzyme responsible for the production of the RNA molecule?

Answer: RNA Polymerase

- Separates the **DNA** molecule by breaking the **H-bonds** between the bases. (Unzips the DNA)
- Then moves along one of the **DNA strands** and lines up complement **RNA** nucleotides with **DNA.**
- Bonds the sugar and phosphate groups of the **RNA** together. Does not bond the nitrogenous bases.
- **RNA** leaves the area between the **DNA** strands.
- **DNA** zips back up.
- **RNA** is processed and leaves the nucleus.

1. Transcription



Question:

- What would be the complementary **RNA** strand for the following **DNA** sequence?

- **DNA GCGTATG**

Answer:

- DNA GCGTATG
- RNA CGCA*U*AC

Practice:

DNA REPLICATION:

- 5’ CTG ACT CCT GAG GAG 3’
- 3’ GAC TGA GGA CTC CTC 5’

DNA to RNA (TRANSCRIPTION):

- 5’ 3’

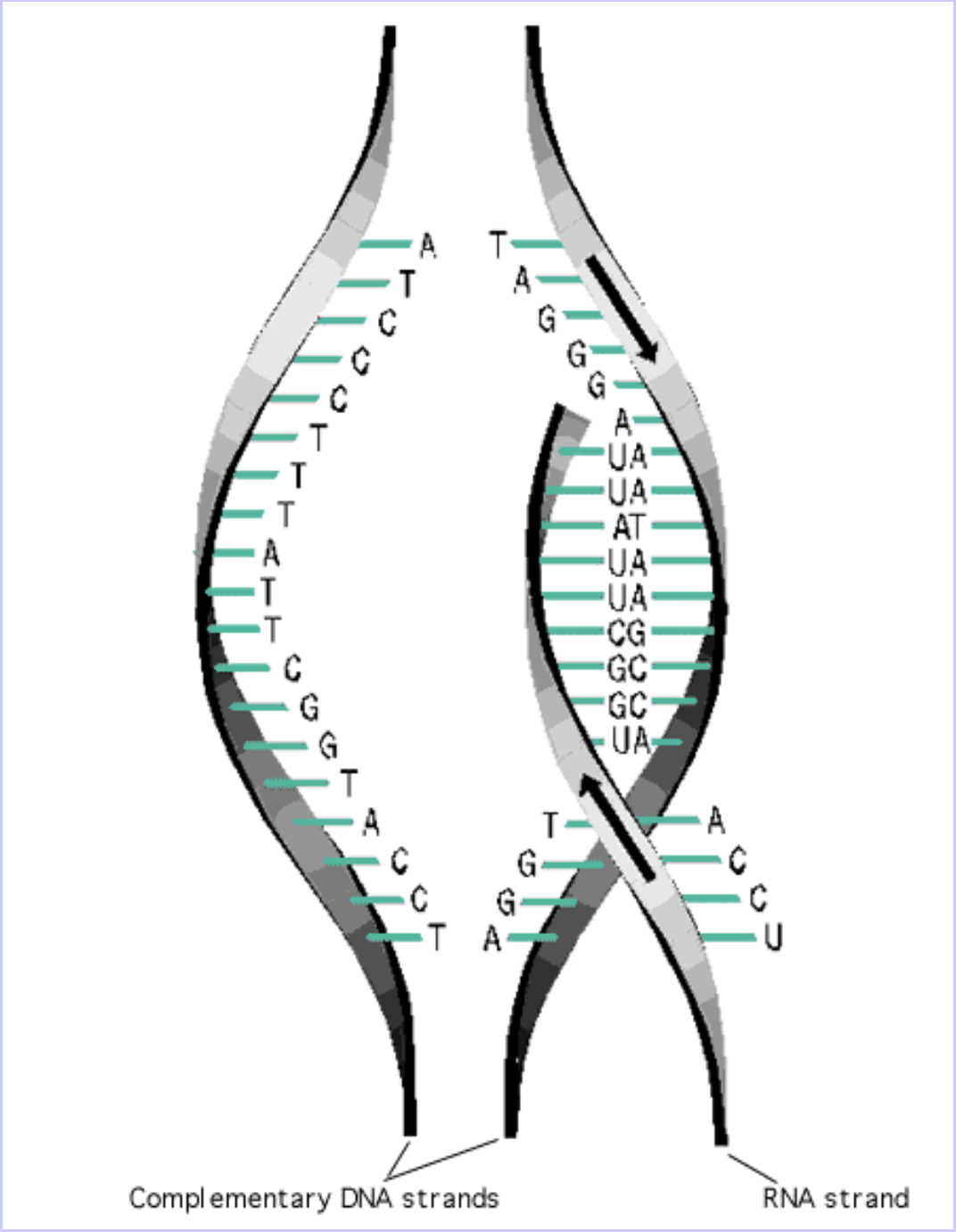
Practice:

DNA REPLICATION:

- 5’ CTG ACT CCT GAG GAG 3’
- 3’ GAC TGA GGA CTC CTC 5’

DNA to RNA (TRANSCRIPTION):

- 5 ’ GAC UGA GGA CUC CUC 3’


A
T
C
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T
T
A
G
G
G
A
UA
UA
AT
UA
UA
CG
GC
GC
UA
T
G
G
A
A
C
C
U
Complementary DNA strands
RNA strand

DNA: transcription video play in – VLC media player

DNA: video clip 23:20-26:15

Types of RNA

- **Types of RNA:**

  A. messenger RNA (mRNA)

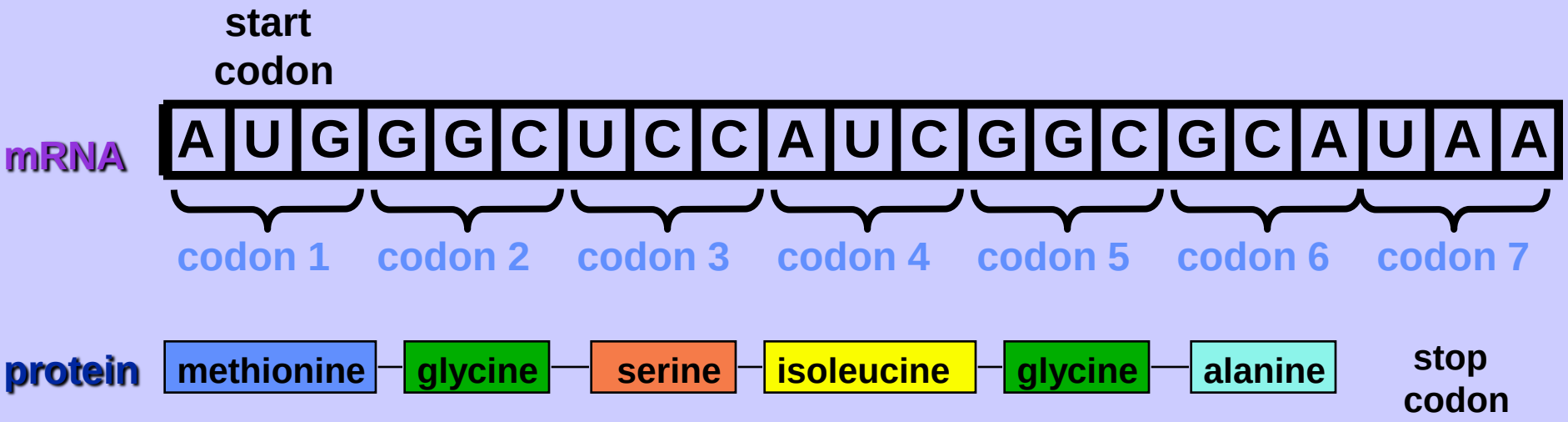
  B. transfer RNA (tRNA)

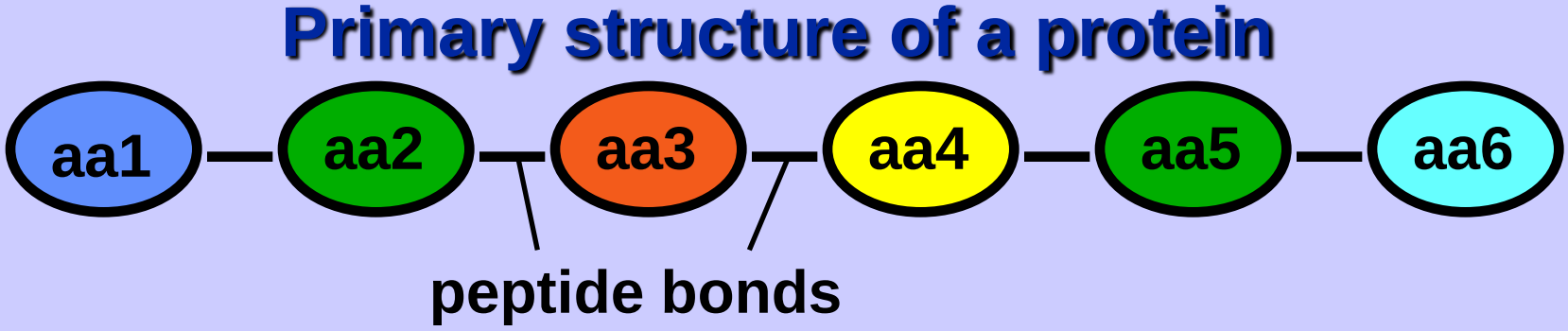
- **Remember: all produced in the nucleus!**

A. Messenger RNA (mRNA)

- Carries the information for a specific **protein**.
- Made up of 500 to 1000 **nucleotides** long.
- Made up of **codons** (**sequence of three bases: AUG - methionine**).
- Each **codon**, is specific for an **amino acid**.

A. Messenger RNA (mRNA)

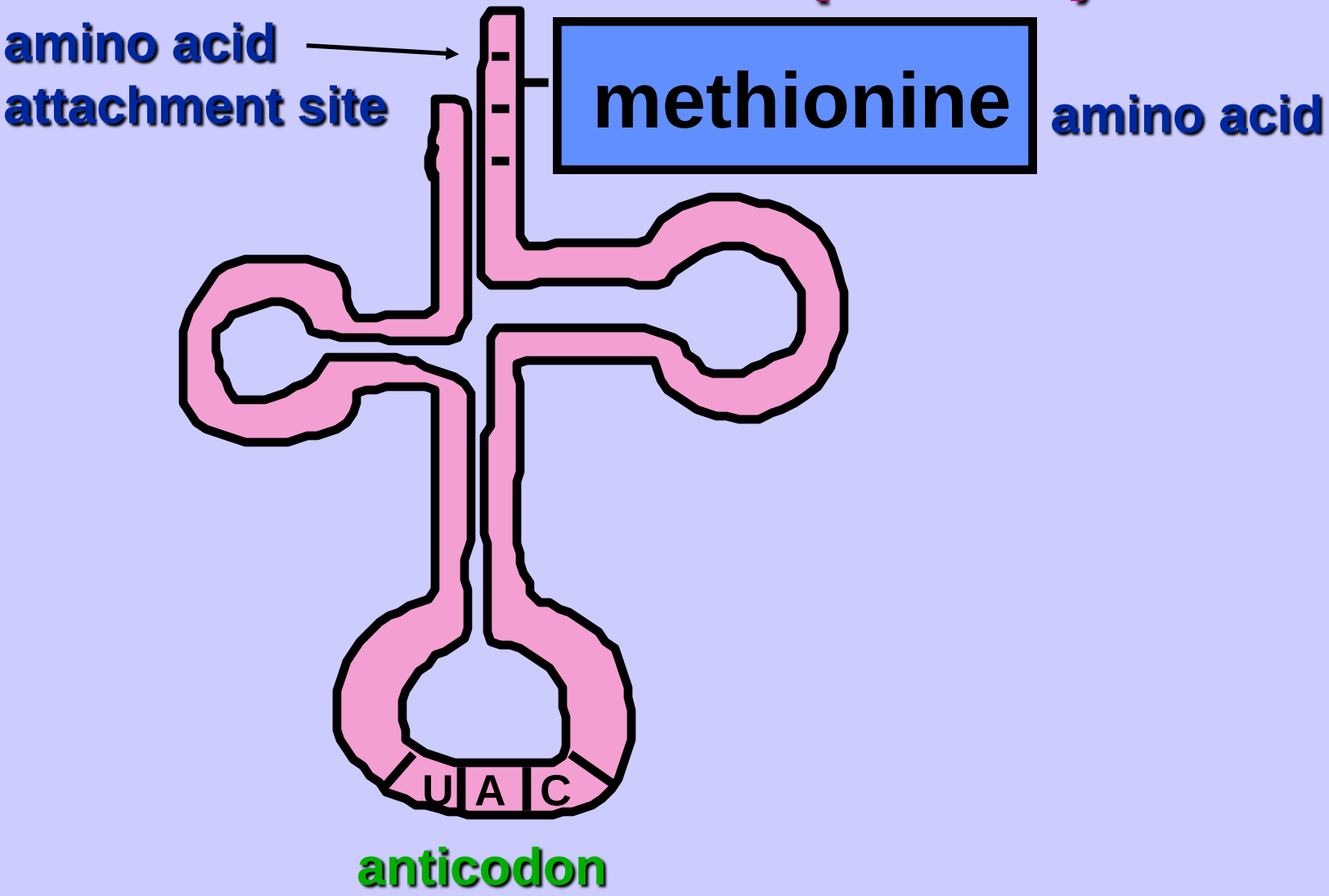




B. Transfer RNA (tRNA)

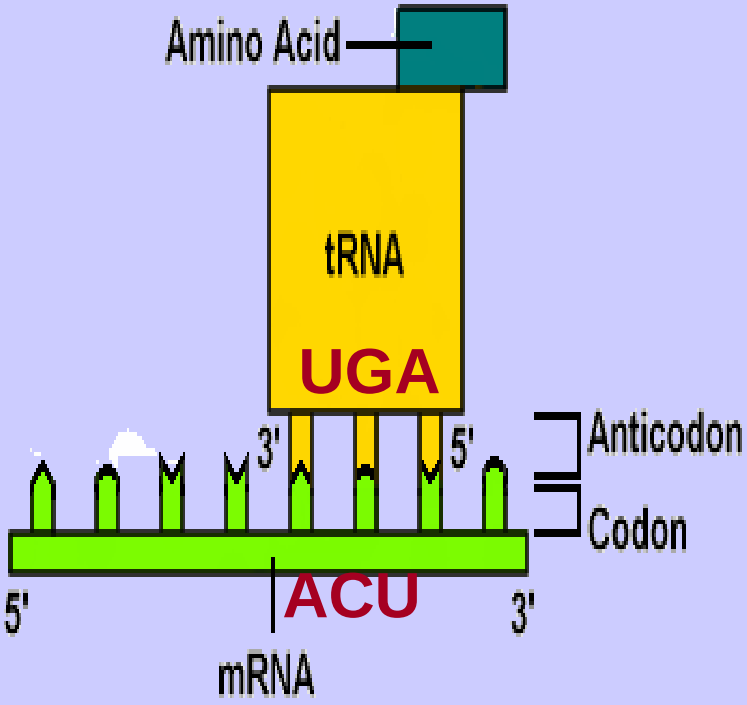
- Made up of 75 to 80 nucleotides long.
- Picks up the appropriate **amino acid** floating in the cytoplasm
- Transports **amino acids** to the **mRNA**.
- Have **anticodons** that are opposites to **mRNA codons**.
- Recognizes the appropriate **codons** on the **mRNA** and bonds temporarily to them

B. Transfer RNA (tRNA)



Codons and Anticodons

- The 3 bases of an anticodon are complementary to the 3 bases of a codon
- Example: Codon ACU
  Anticodon UGA

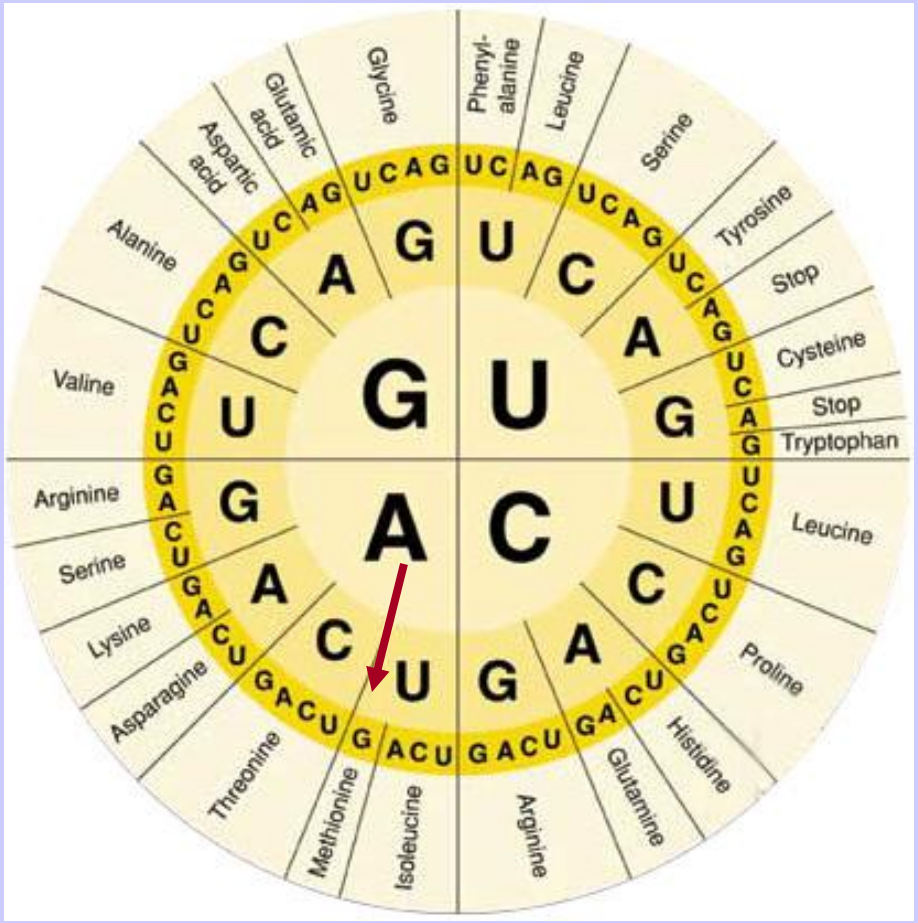


The Genetic Code

- A codon designates an amino acid
- An amino acid may have more than one codon
- There are 20 amino acids, but 64 possible codons
- Some codons tell the ribosome to *stop* translating

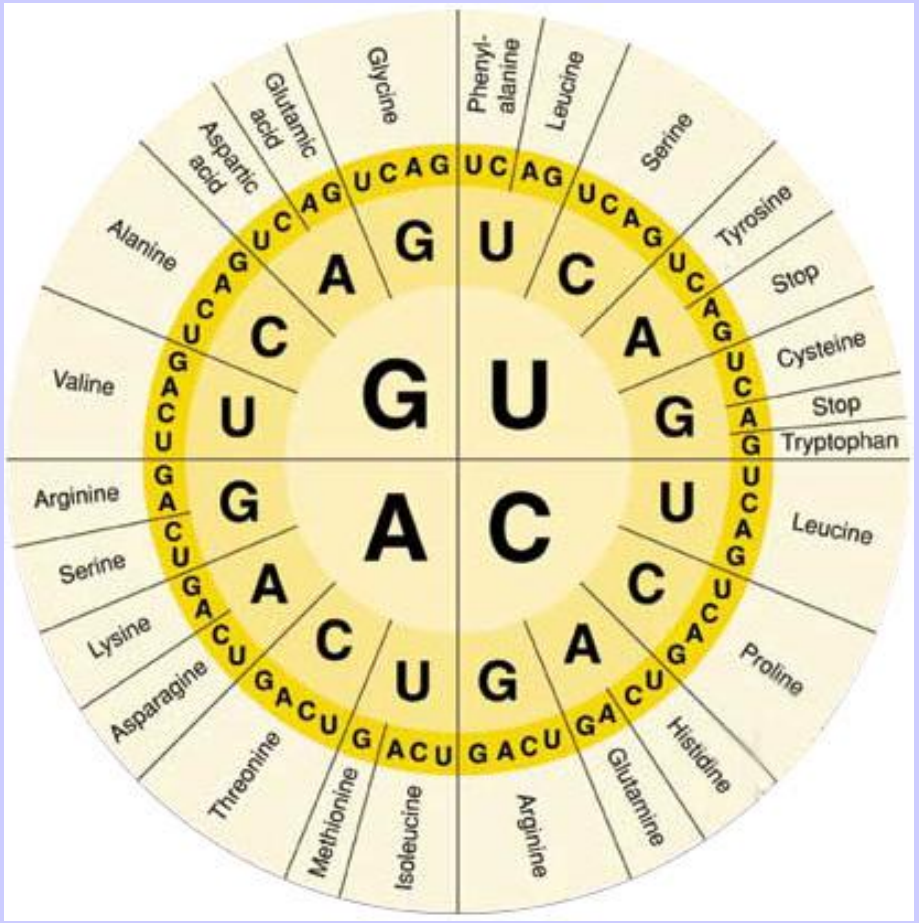
The Genetic Code

- Use the code by reading from the center to the outside
- Example: AUG codes for Methionine



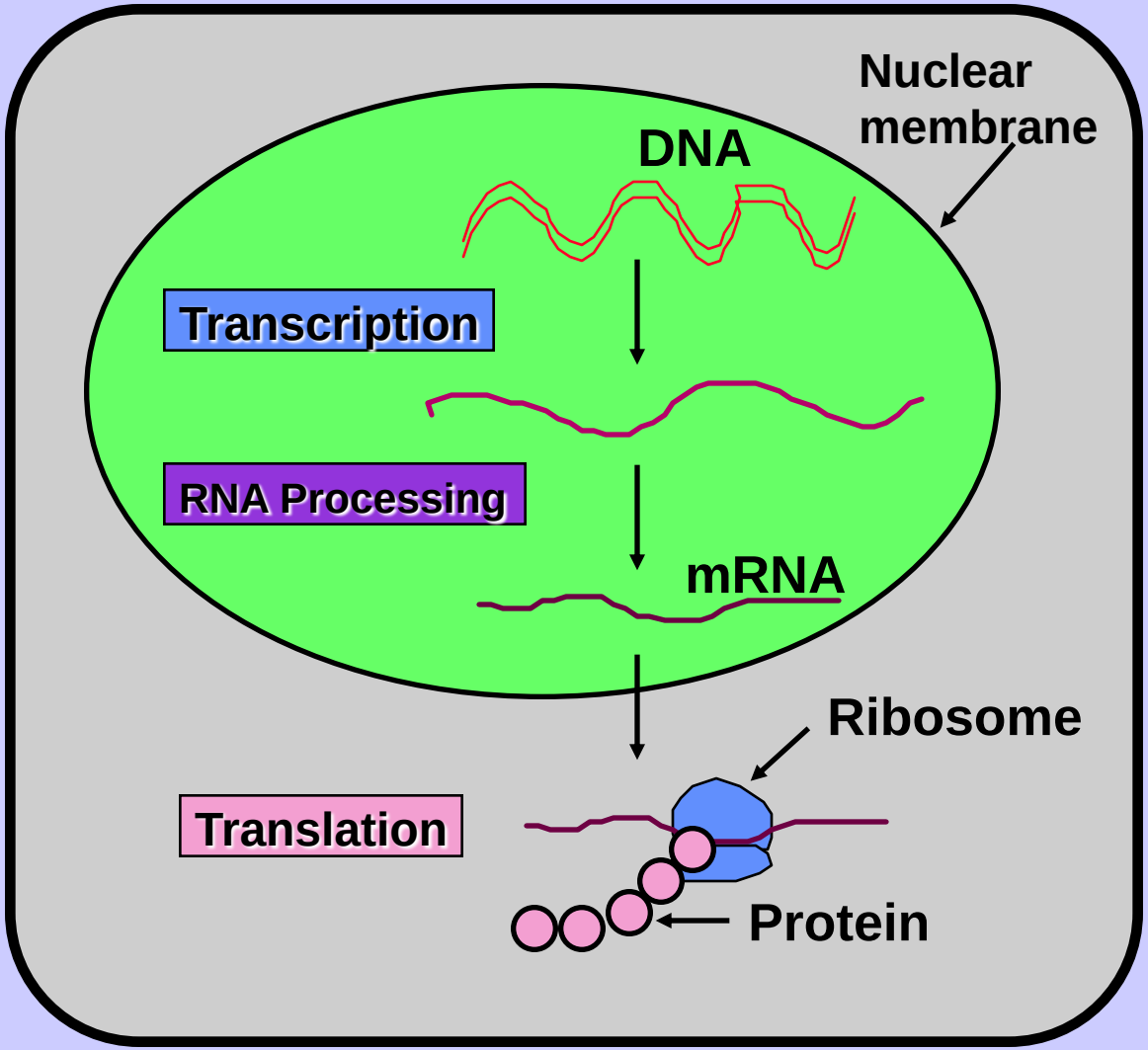
Name the Amino Acids

- GGG?
- UCA?
- CAU?
- GCA?
- AAA?



2. RNA Processing

Eukaryotic Cell



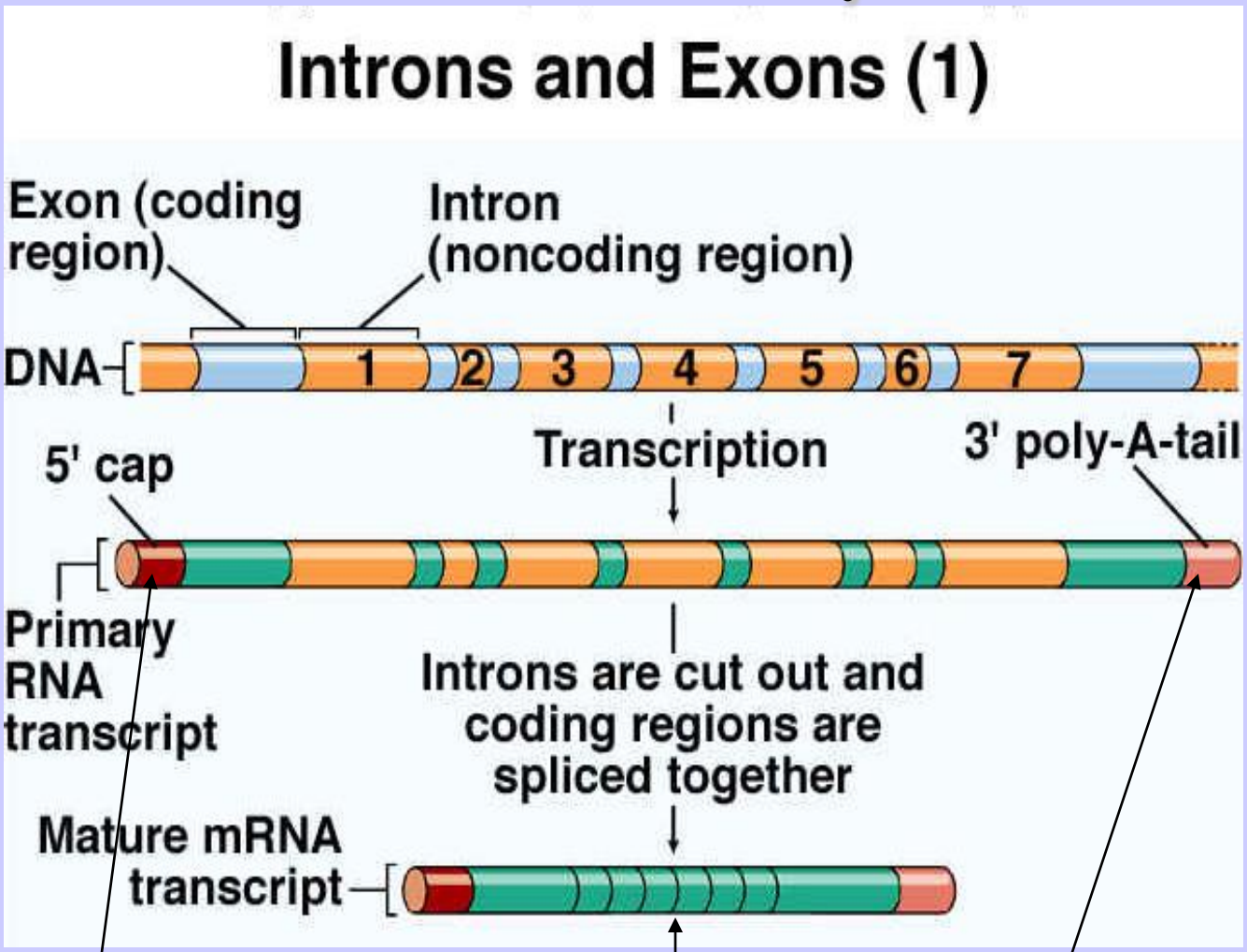
mRNA Processing

- After the DNA is transcribed into RNA, editing must be done to the nucleotide chain to make the RNA functional
- Introns, non-functional segments of DNA are snipped out of the chain

mRNA Editing

- Exons, segments of DNA that code for proteins, are then rejoined by the enzyme (ligase)
- A guanine triphosphate cap is added to the 5" end of the newly copied mRNA
- A poly A tail is added to the 3' end of the RNA
- The newly processed mRNA can then leave the nucleus

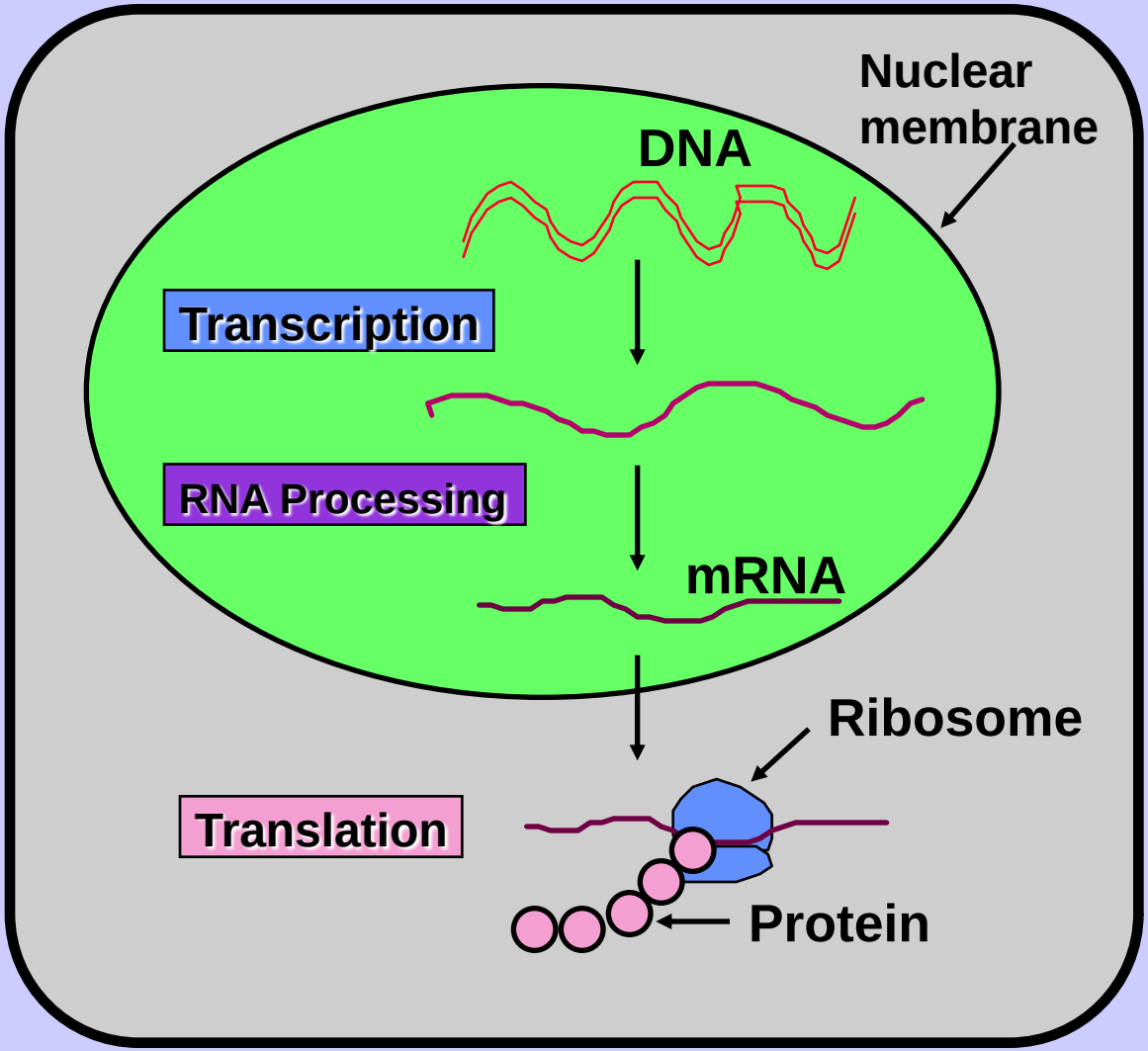
Result of Transcription



DNA: video
play in – VLC media player
26:15-29:14)
stop at restriction enzymes

3. Translation

Eukaryotic Cell



3. Translation

- Synthesis of **proteins** in the **cytoplasm**
- **Involves the following:**
  1. **mRNA (codons)**
  2. **tRNA (anticodons)**
  3. **ribosomes**
  4. **amino acids**

3. Translation

- Three parts:
  1. **initiation**: start codon (AUG)
  2. **elongation**: building the polypeptide chain
  3. **termination**: stop codon (UAG)

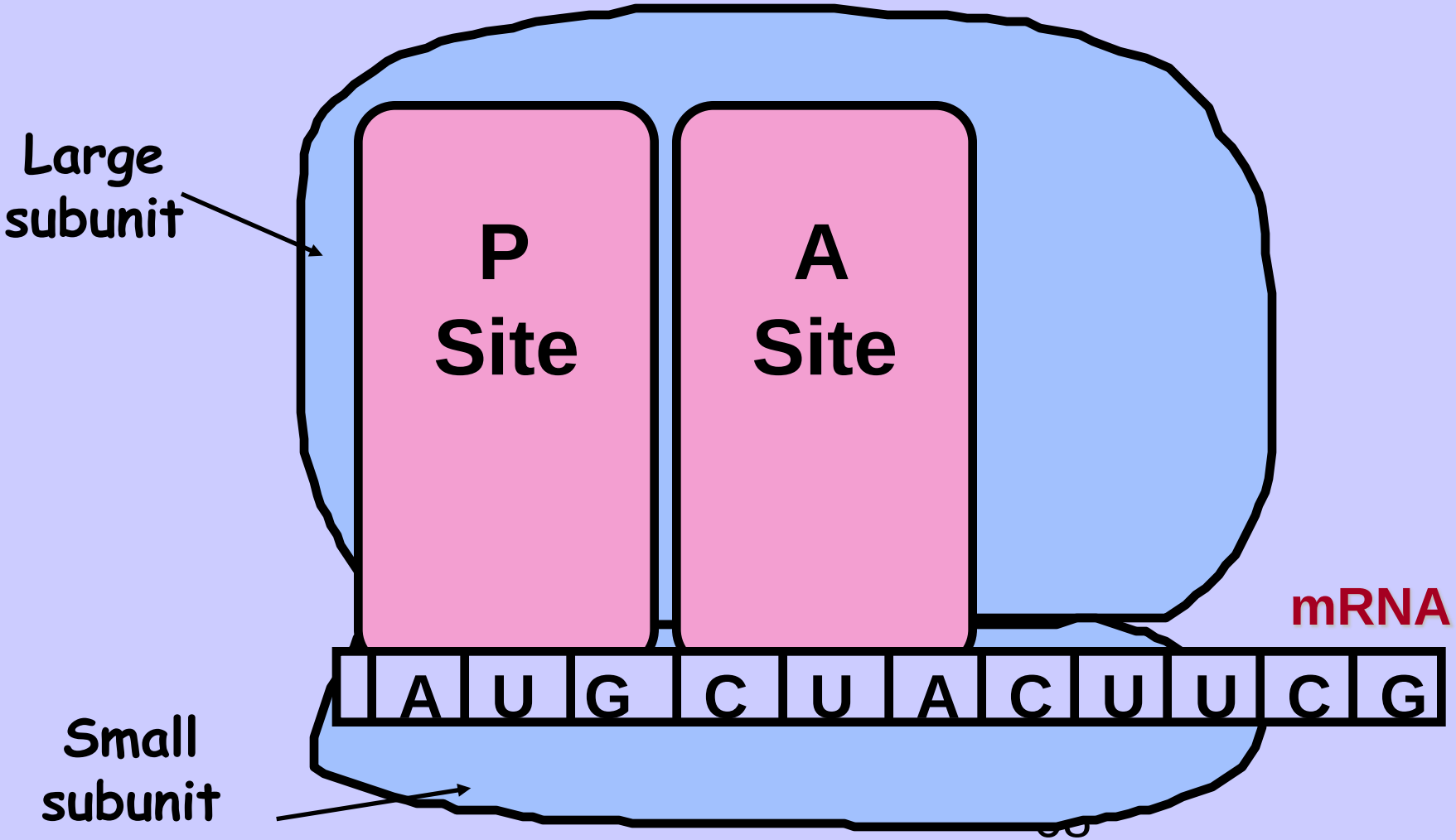
- Let's make a **PROTEIN!!!!**.

Translation animation
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf

3. Translation

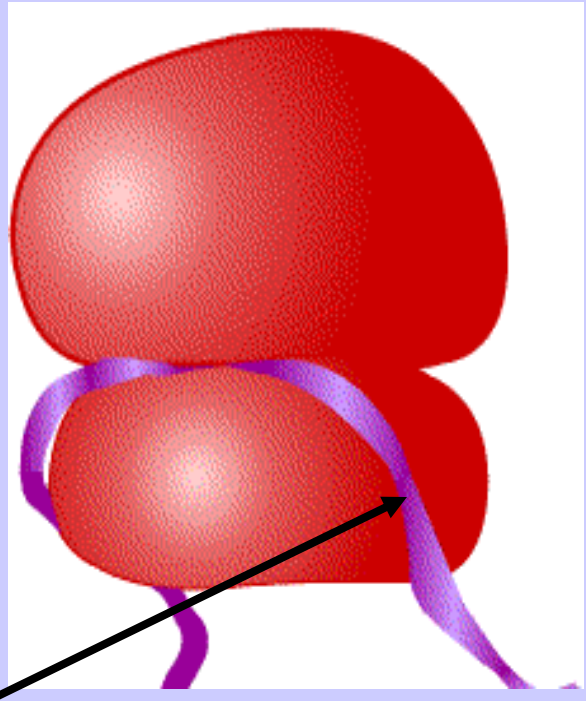
- **Translation is the process of decoding the mRNA into a polypeptide chain**
- **Ribosomes read mRNA three bases or 1 codon at a time and construct the proteins**

3. Translation



Step 1- Initiation

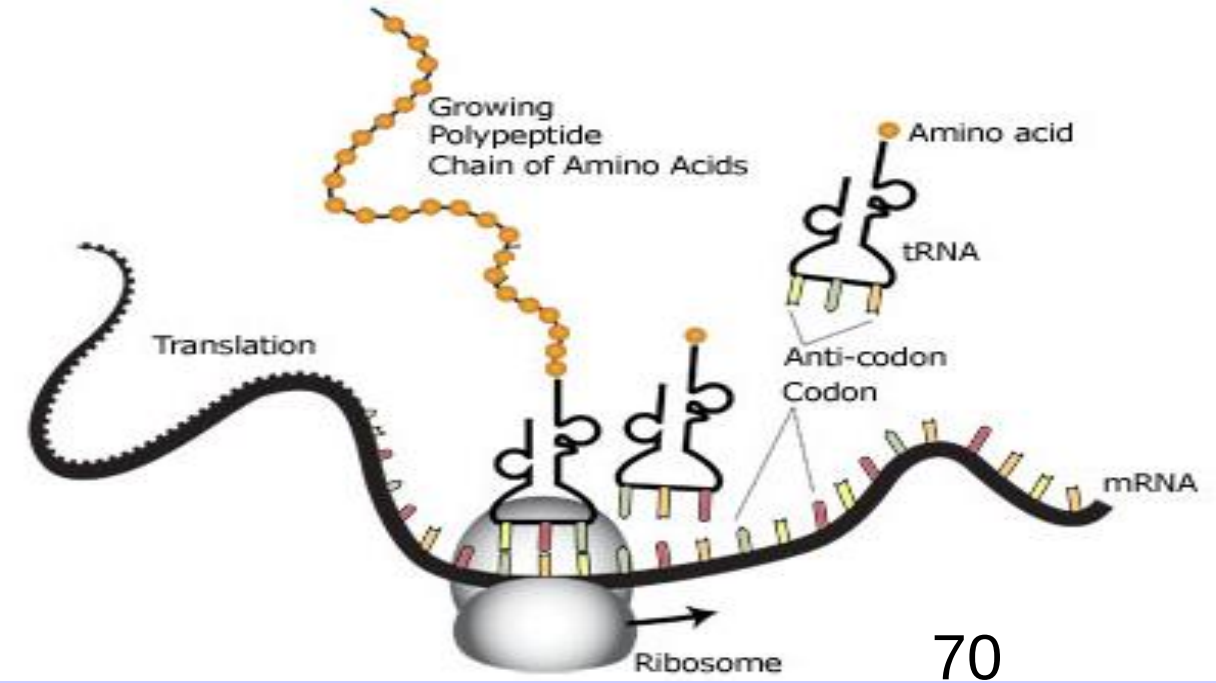
- mRNA transcript start codon AUG attaches to the small ribosomal subunit
- Small subunit attaches to large ribosomal subunit



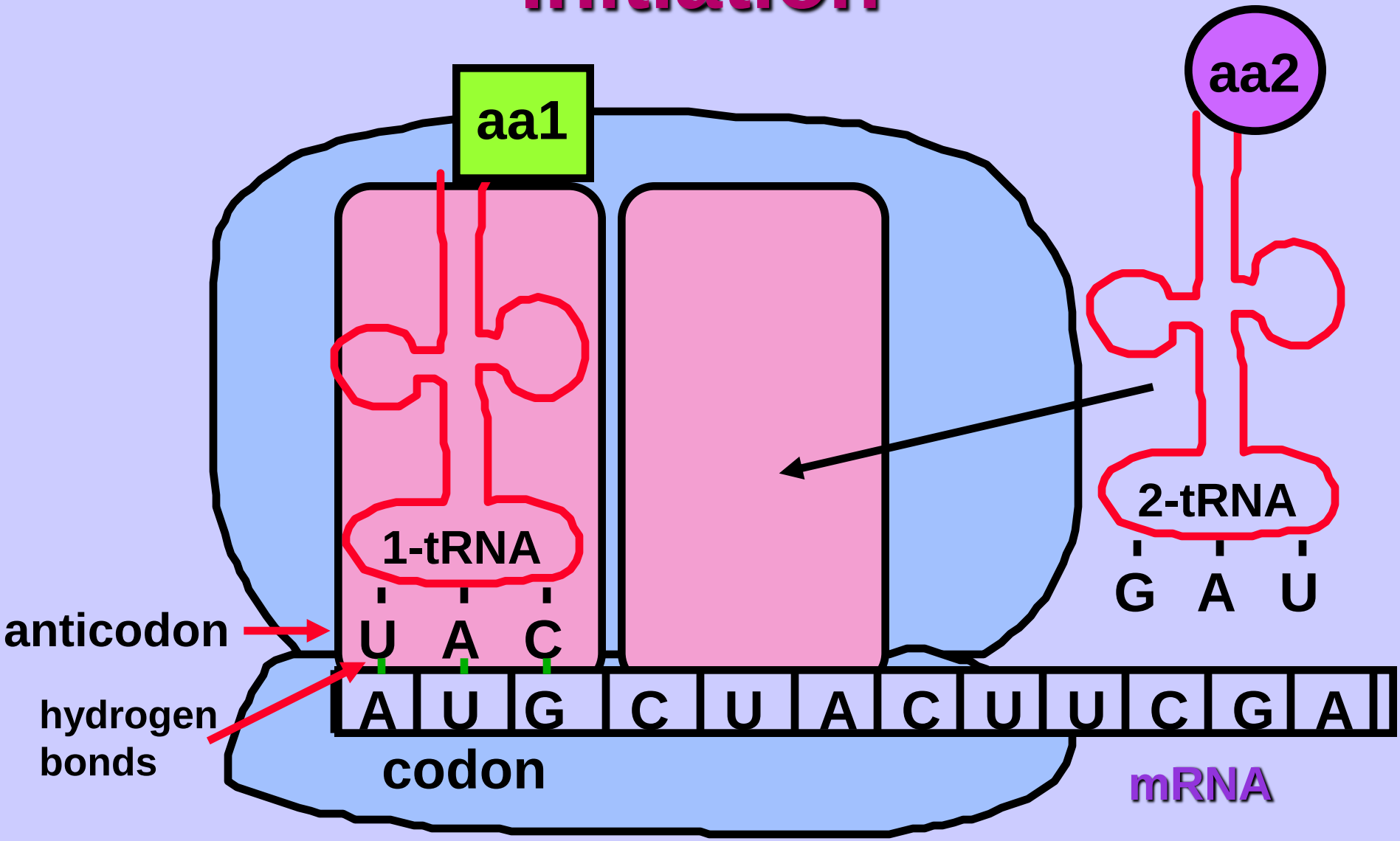
mRNA transcript

Step 2 - Elongation

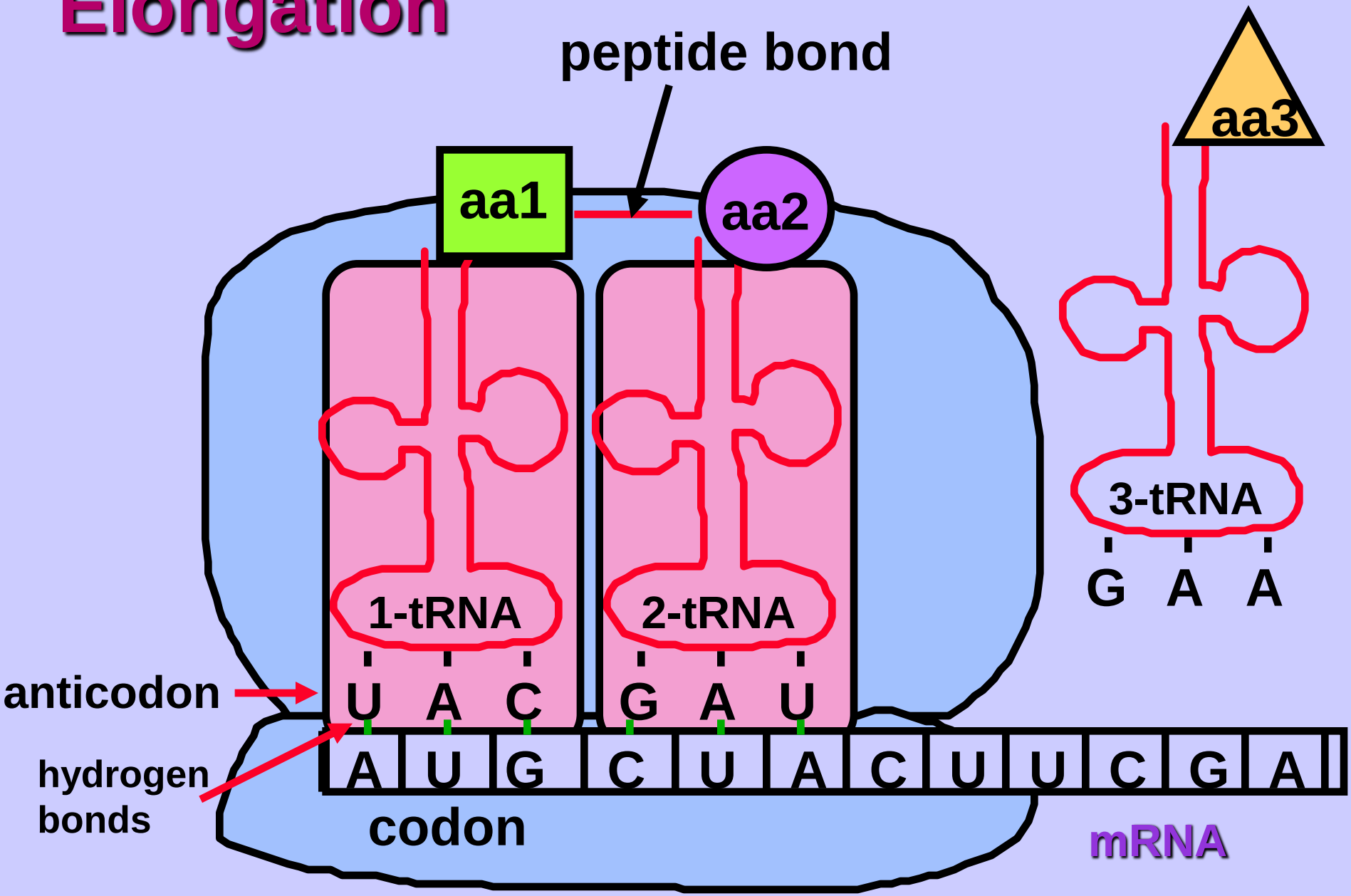
- As ribosome moves, two tRNA with their amino acids move into site A and P of the ribosome
- Peptide bonds join the amino acids

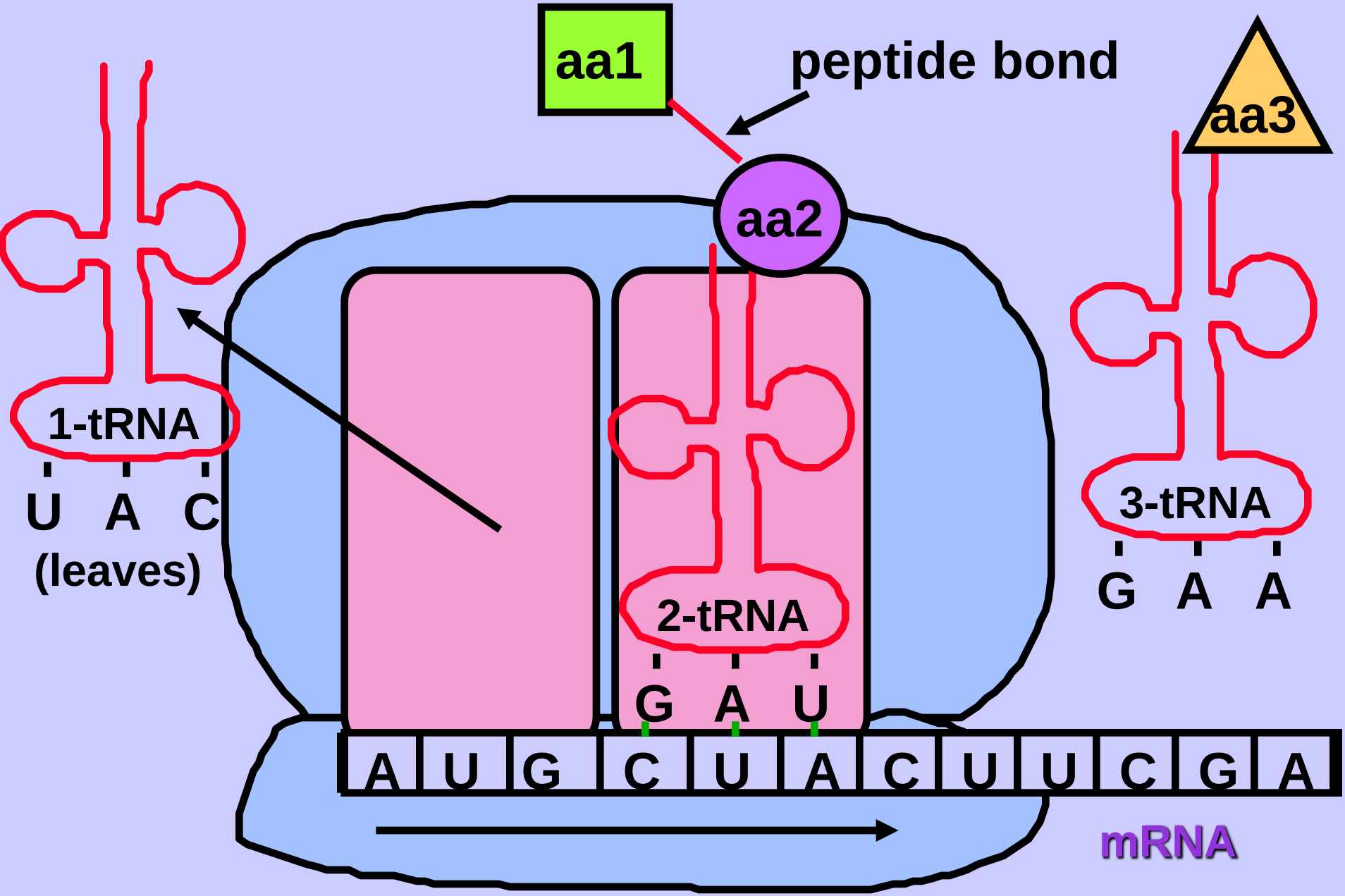


Initiation

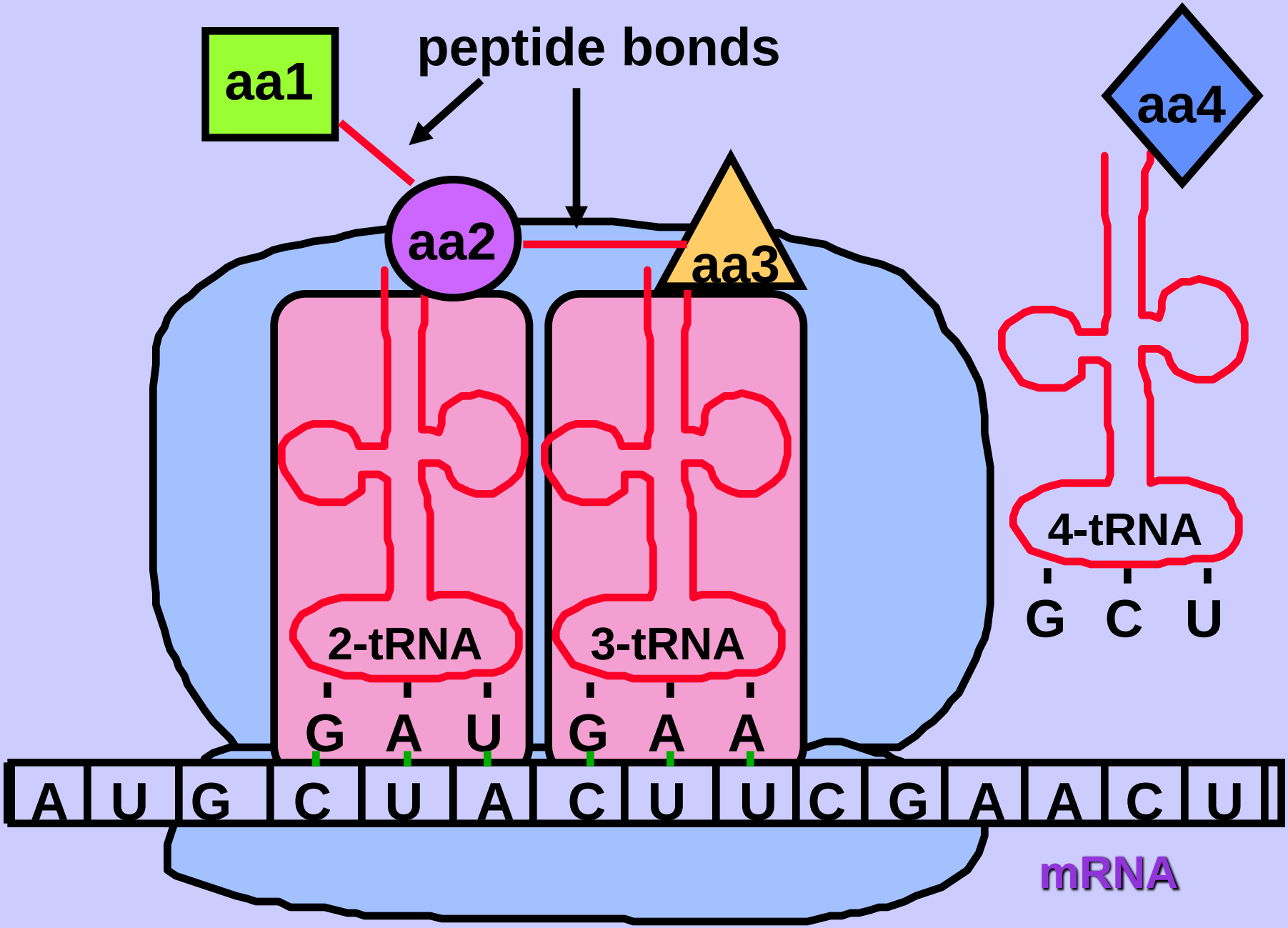

aa1
aa2
1-tRNA
2-tRNA
U A C
G A U
anticodon
hydrogen bonds
A U G C U A C U U C G A
codon
mRNA

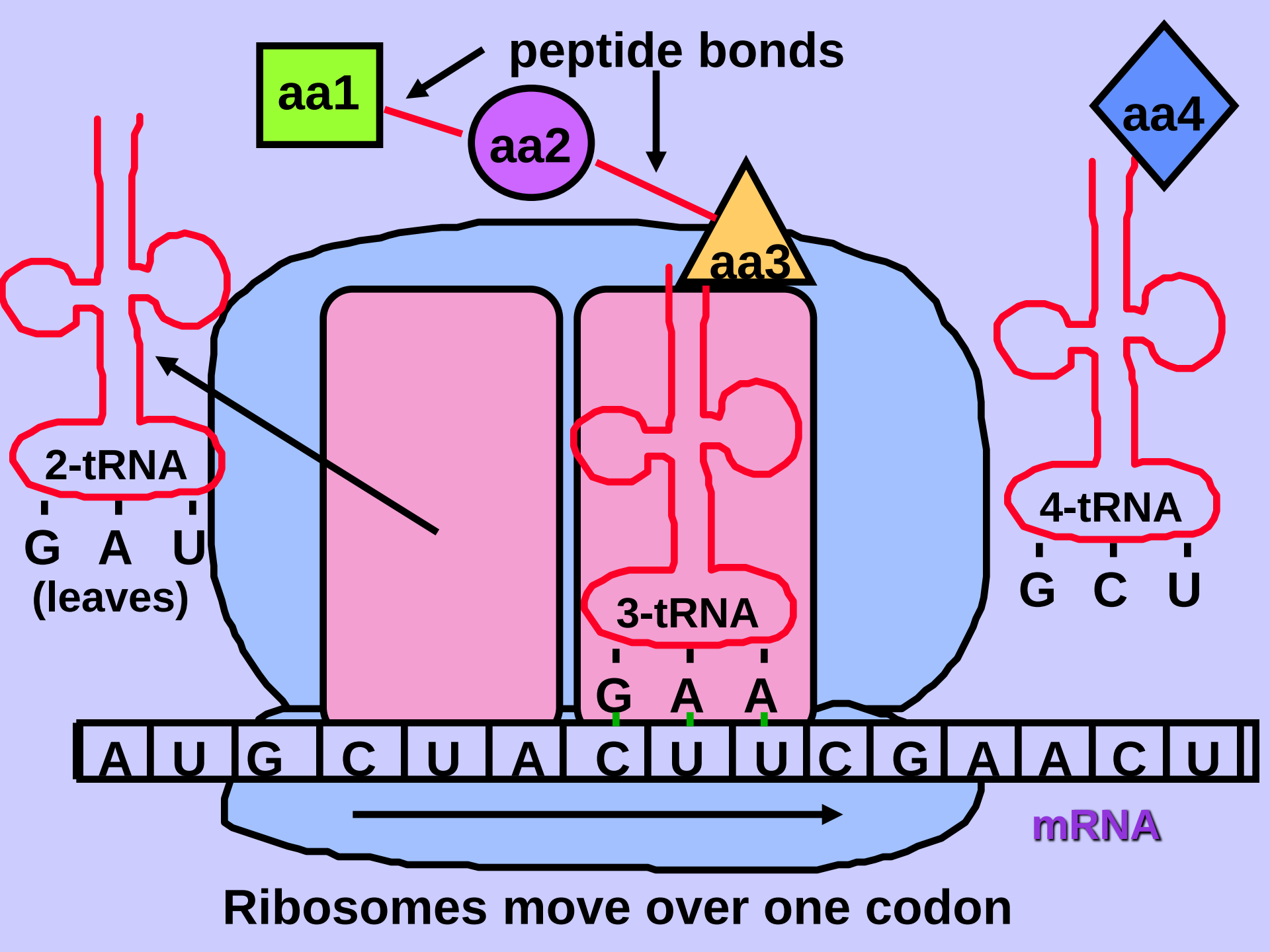
Elongation

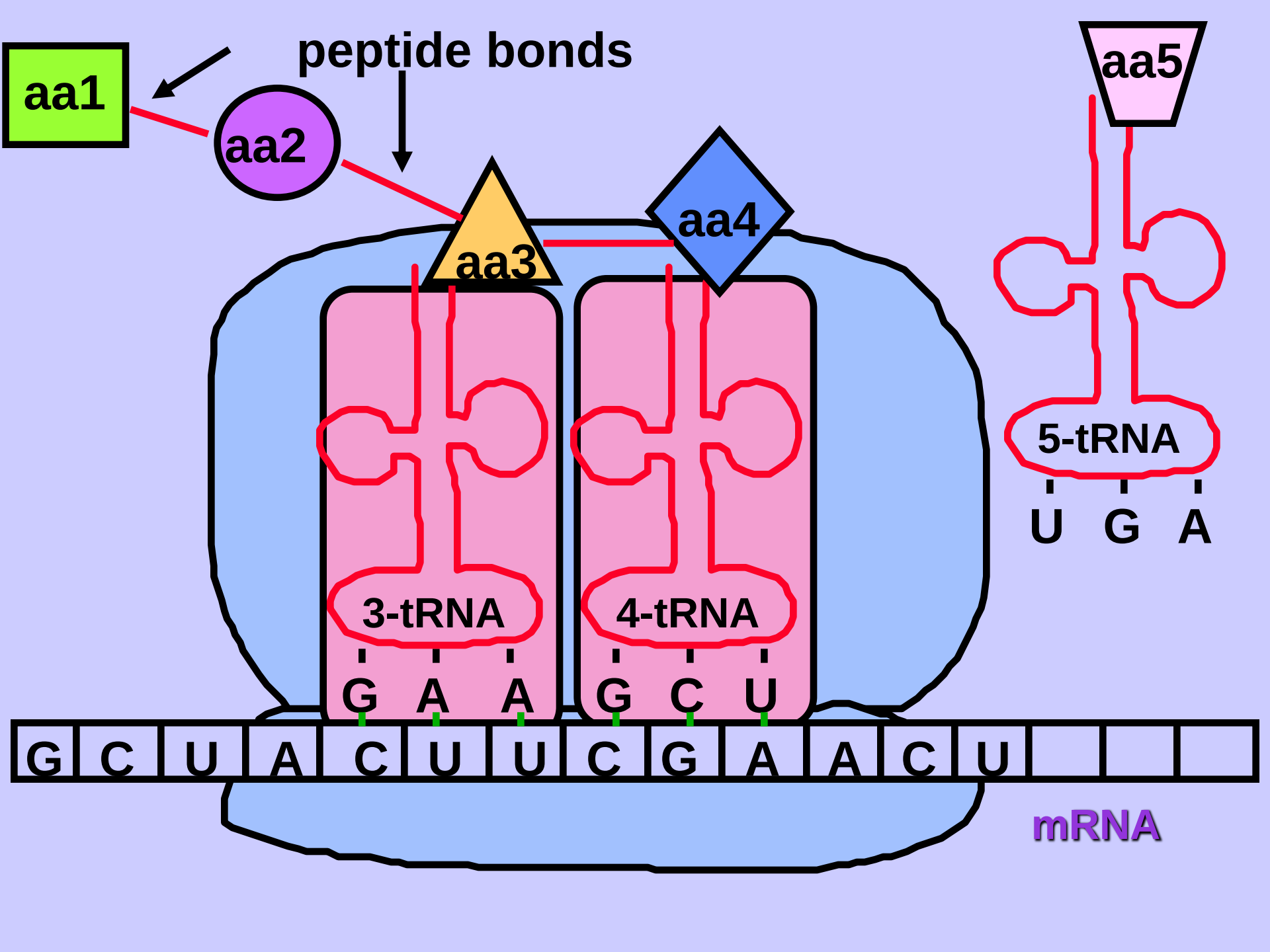

peptide bond
aa1
aa2
aa3
1-tRNA
2-tRNA
3-tRNA
G A A
anticodon
U A C
G A U
hydrogen bonds
A U G C U A C U U C G A
codon
mRNA

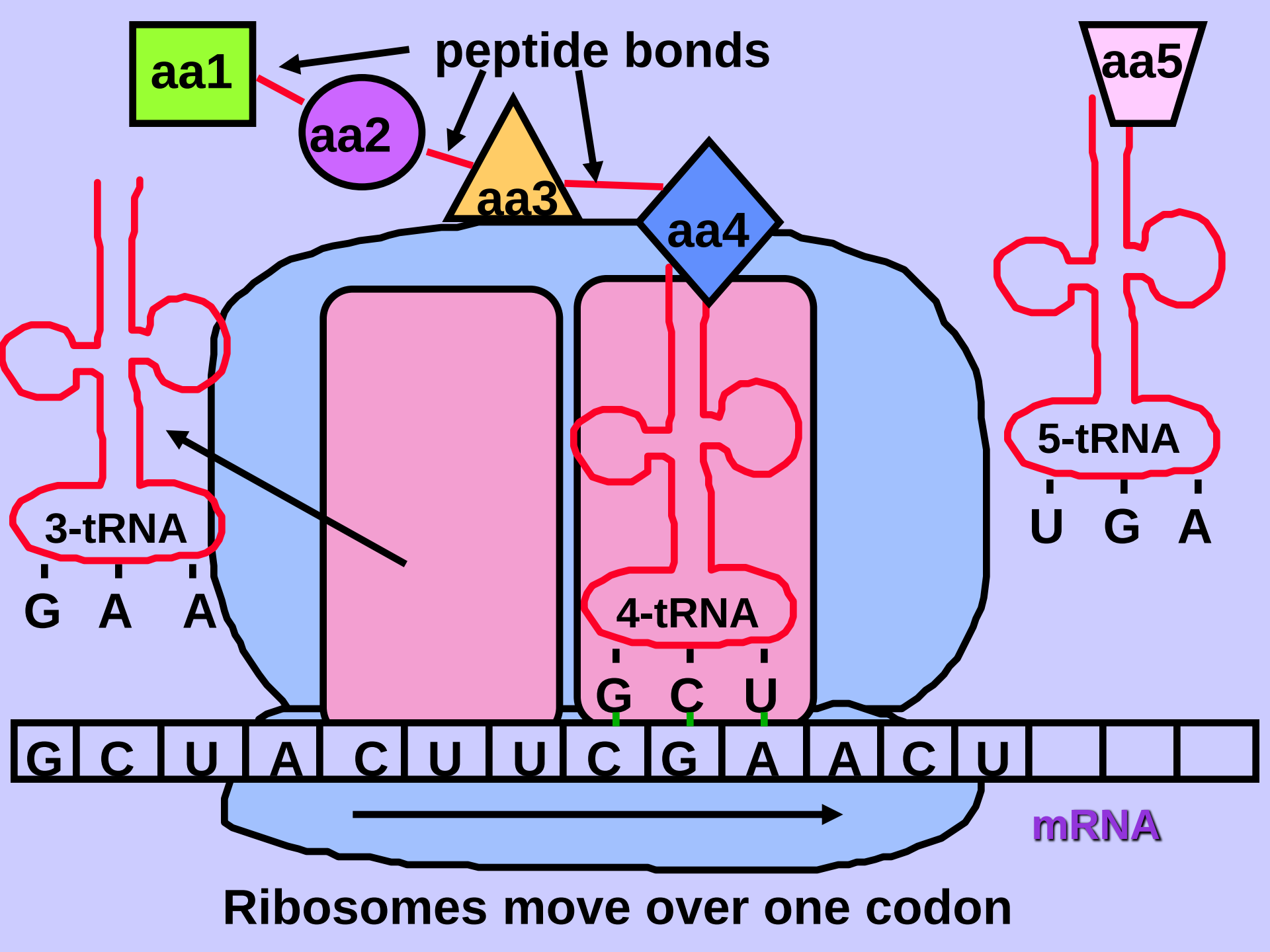


Ribosomes move over one codon

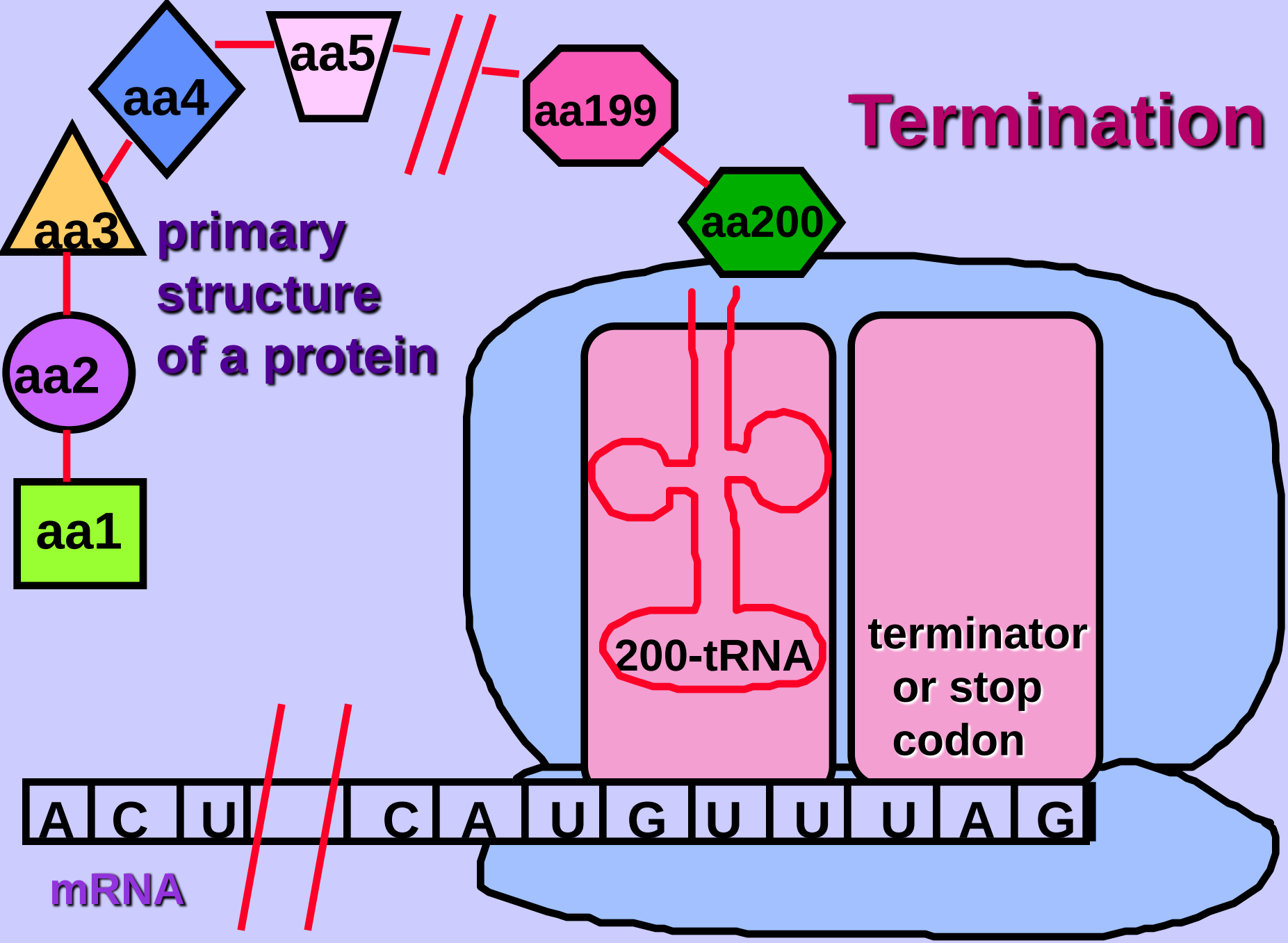

aa1
peptide bonds
aa4
aa2
aa3
4-tRNA
G C U
2-tRNA
3-tRNA
G A U
G A A
A U G C U A C U U C G A A C U
mRNA


peptide bonds
aa1
aa2
aa3
aa4
2-tRNA
G A U
(leaves)
3-tRNA
G A A
4-tRNA
G C U
A U G C U A C U U C G A A C U
mRNA
Ribosomes move over one codon


aa1
aa2
peptide bonds
aa3
aa4
aa5
3-tRNA
4-tRNA
5-tRNA
G A A
G C U
U G A
G C U A C U U C G A A C U
mRNA


aa1
aa2
peptide bonds
aa3
aa4
aa5
3-tRNA
G A A
4-tRNA
G C U
5-tRNA
U G A
G C U A C U U C G A A C U
mRNA
Ribosomes move over one codon

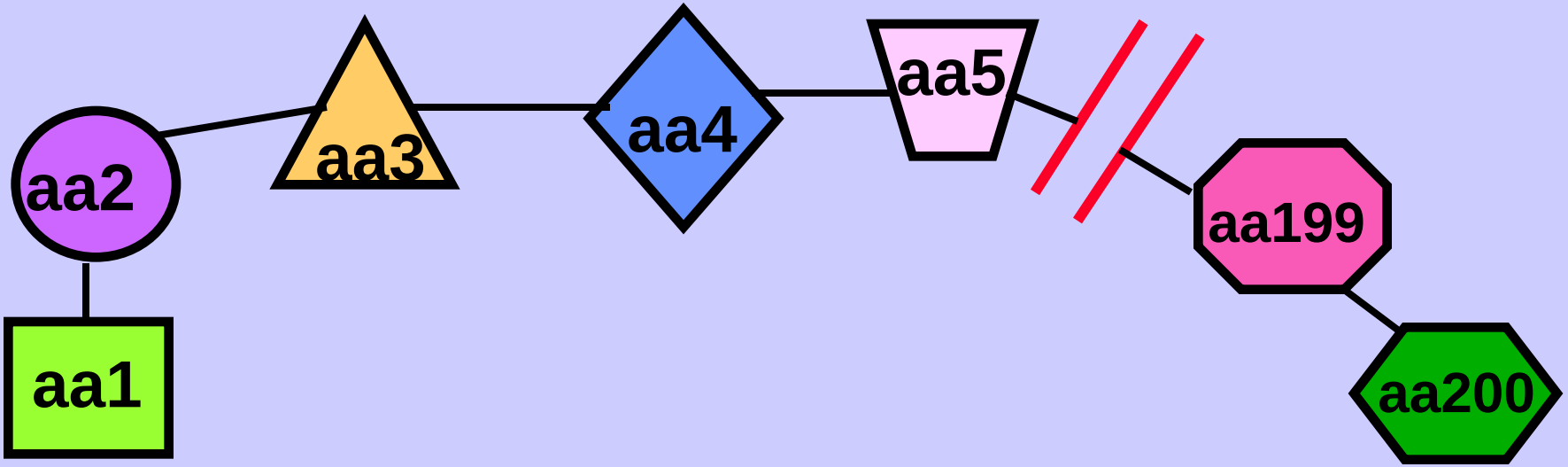
Termination



http://learn.genetics.utah.edu/content/begin/dna/transcribe/

End Product

- The end products of protein synthesis are the **primary structure of a protein**.
- A sequence of **amino acid** bonded together by **peptide bonds**.



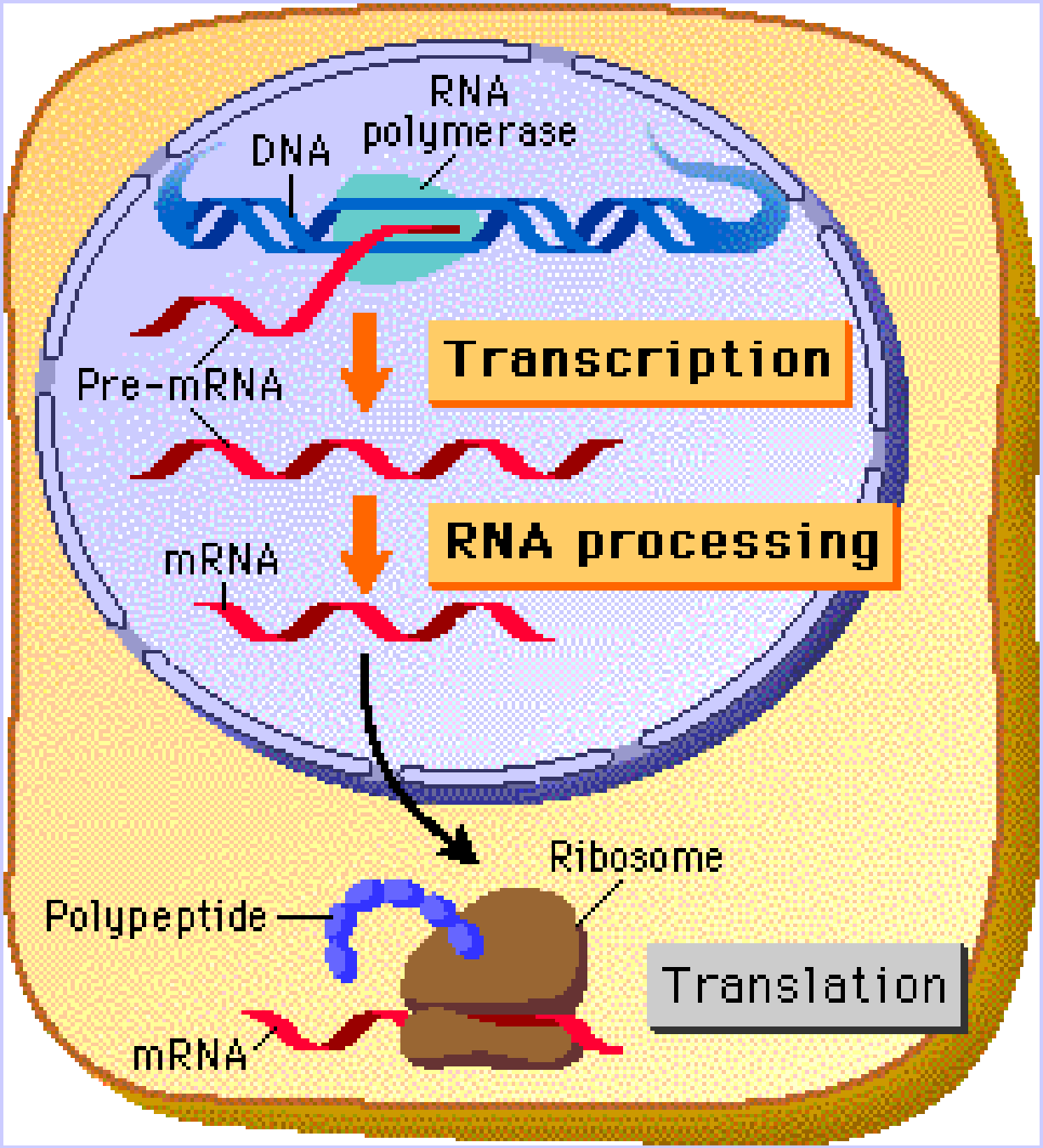
Question:

- The anticodon **UAC** belongs to a **tRNA** that recognizes and binds to a particular **amino acid**.

- What would be the **DNA base code** for this **amino acid?**

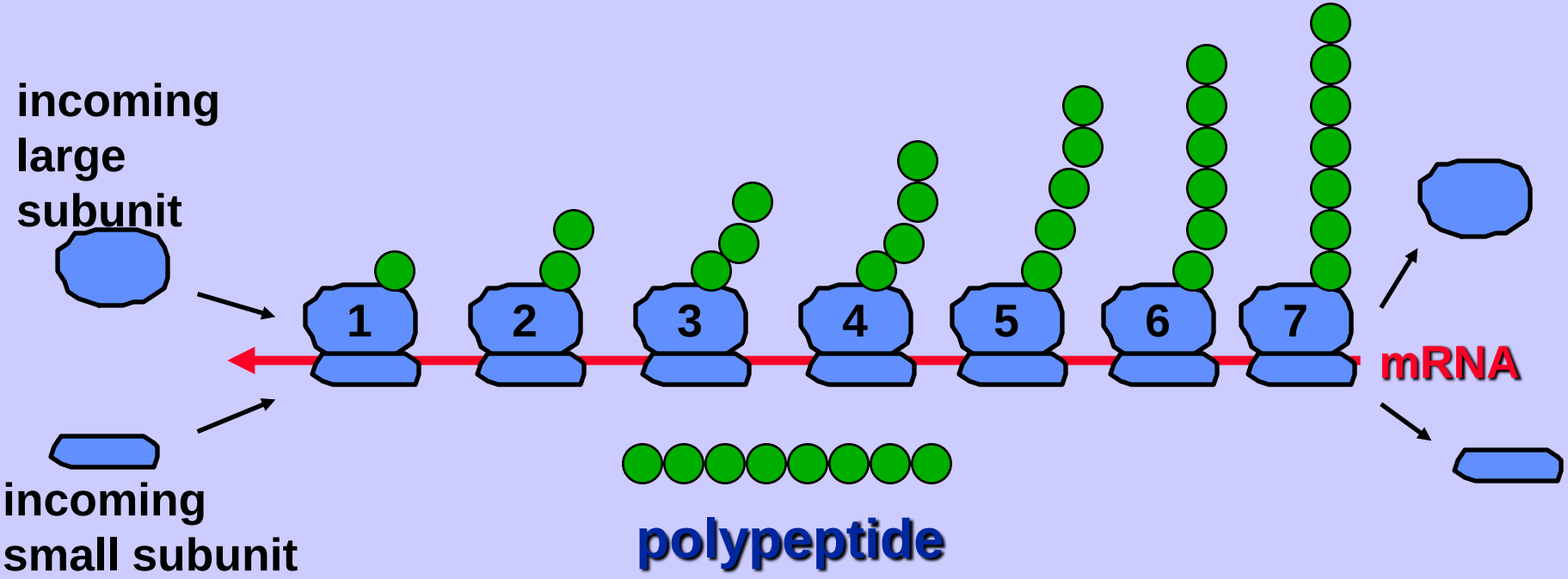
Answer:

- tRNA - UAC (anticodon)
- mRNA - AUG (codon)
- DNA - TAC


RNA polymerase
DNA
Pre-mRNA
Transcription
mRNA
RNA processing
Ribosome
Polypeptide
Translation
mRNA

Polyribosome

- Groups of ribosomes reading same **mRNA** simultaneously producing many **proteins (polypeptides).**

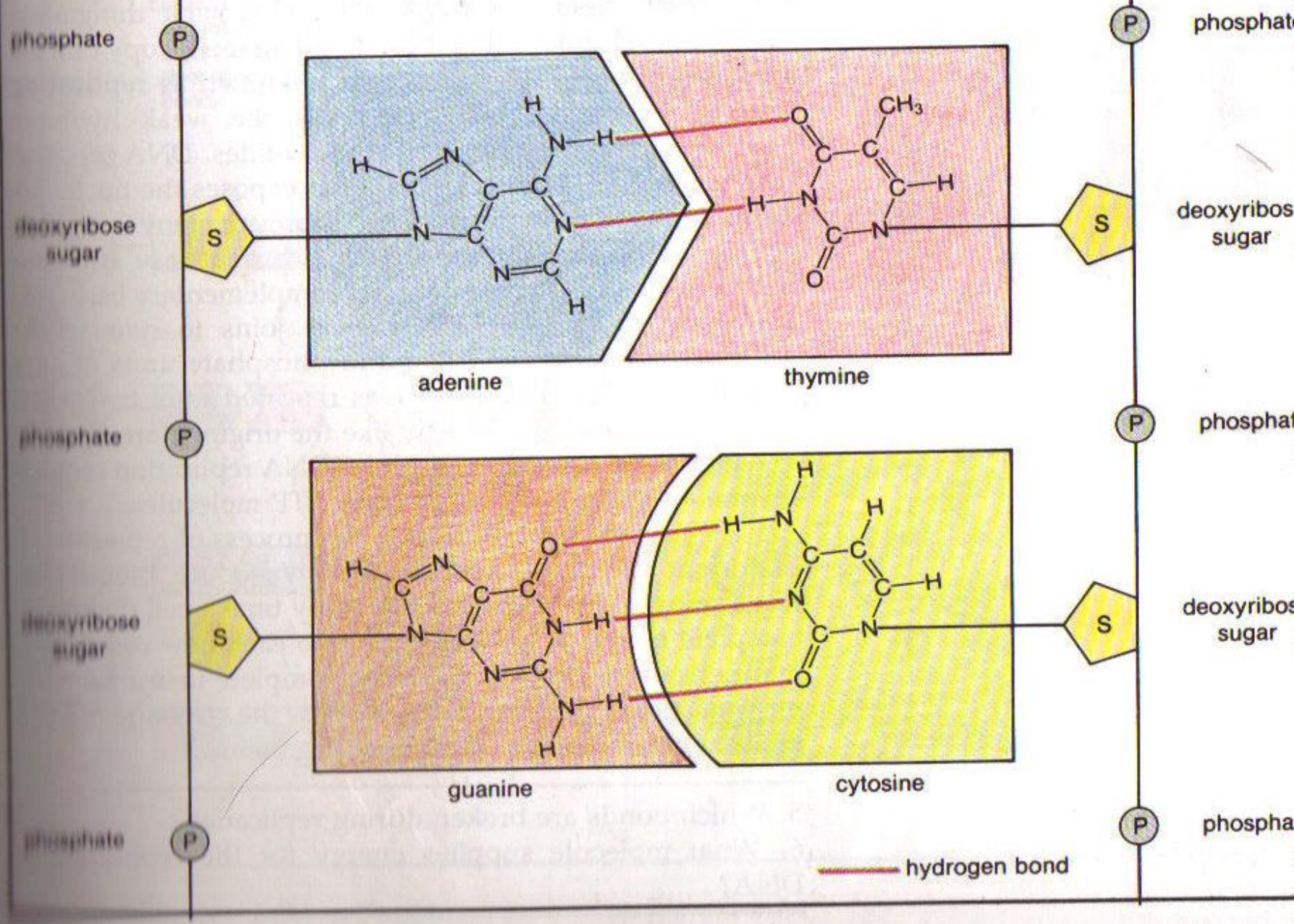


http://learn.genetics.utah.edu/content/molecules/transcribe/

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf

unzip a simplified dna, showing bases
show pool of free nucleotides
fill in complementary nucleotides
sugars/phosphates bond
end with 2 identical dna strands


phosphate
P
deoxyribose sugar
S
adenine
thymine
guanine
cytosine
hydrogen bond

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

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf

unzip a simplified dna, showing bases
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