SPI 4.1: I can identify the structure and function of DNA.

Kickoff:

Nucleotide:_____::nucleic acid:polymer

Recall from standard 1.3, define what a nucleotide is with an illustration.

8.2 Structure of DNA

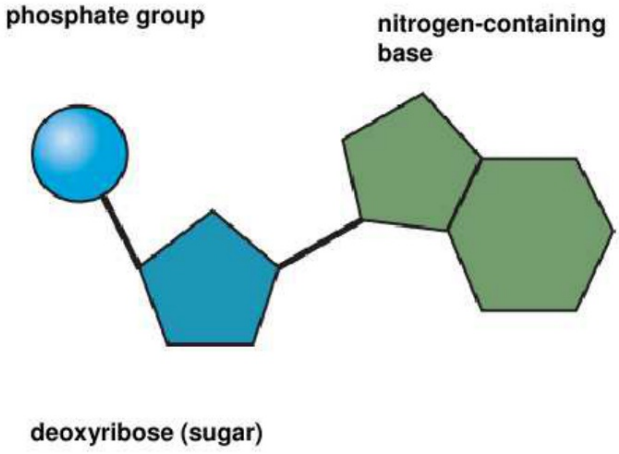
KEY CONCEPT

DNA structure is the same in all organisms.

8.2 Structure of DNA

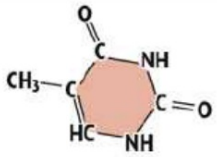
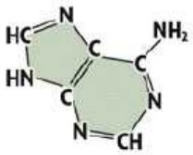
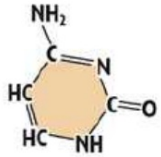
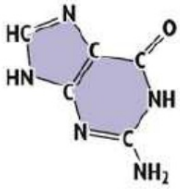
DNA is composed of four types of nucleotides.

- DNA is made up of a long chain of nucleotides.
- Each nucleotide has three parts.
  - a phosphate group
  - a deoxyribose sugar
  - a nitrogen-containing base



8.2 Structure of DNA

- The nitrogen containing bases are the only difference in the four nucleotides.

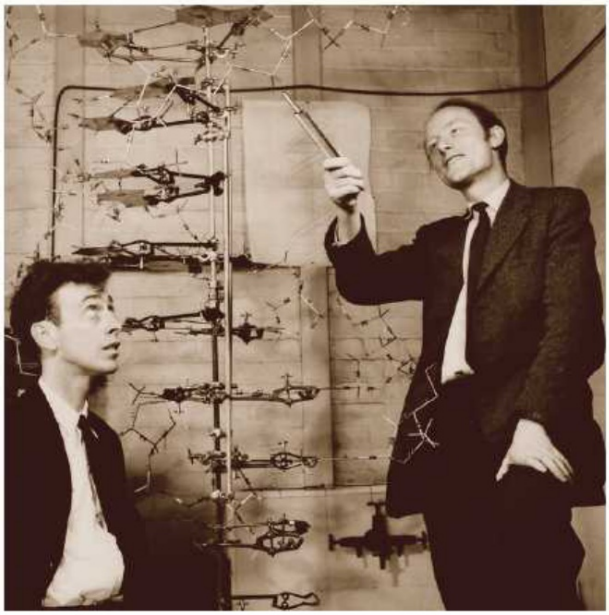
PYRIMIDINES = SINGLE RING			PURINES = DOUBLE RING		
Name of Base	Structural Formula	Model	Name of Base	Structural Formula	Model
thymine			adenine		
cytosine			guanine		

Pair

Pair

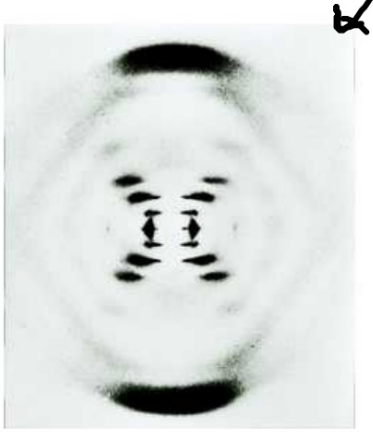
8.2 Structure of DNA

- **Watson and Crick determined the three-dimensional structure of DNA by building models.**
  - They realized that DNA is a double helix that is made up of a sugar-phosphate backbone on the outside with bases on the inside.



8.2 Structure of DNA

- Watson and Crick's discovery built on the work of Rosalind Franklin and Erwin Chargaff.
  - Franklin's x-ray images suggested that DNA was a double helix of even width.
  - Chargaff's rules stated that A=T and C=G.



8.2 Structure of DNA

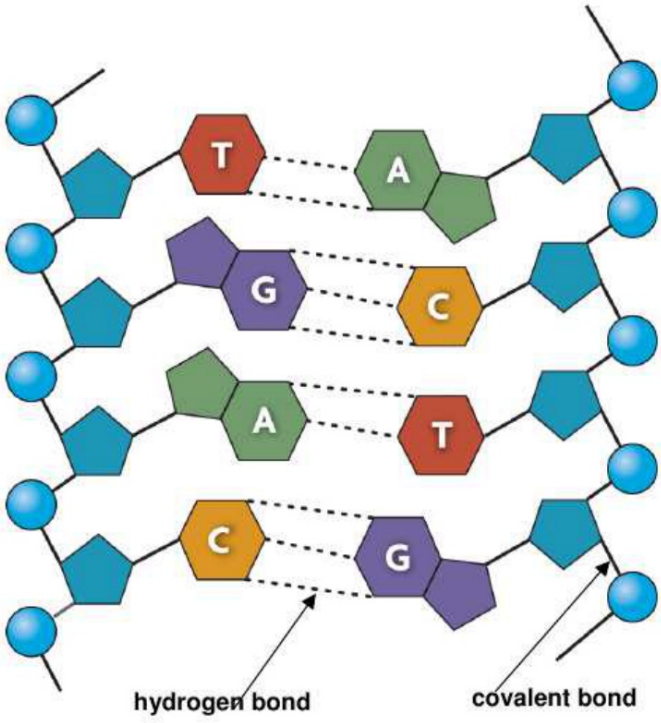
Nucleotides always pair in the same way.

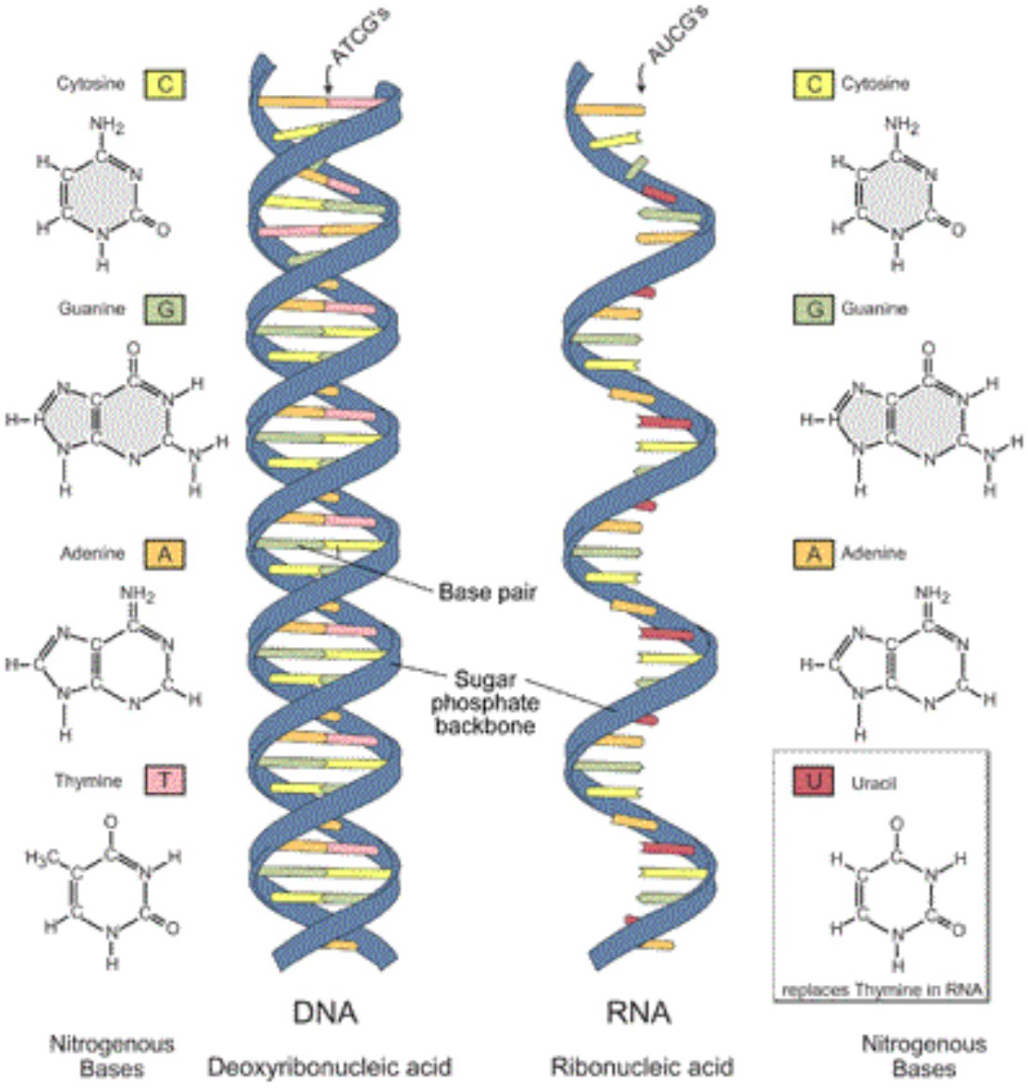
- The base-pairing rules show how nucleotides always pair up in DNA.
  - A pairs with T
  - C pairs with G
- Because a pyrimidine (single ring) pairs with a purine (double ring), the helix has a uniform width.

base pai-
two nucle
bonded +

8.2 Structure of DNA

- The backbone is connected by covalent bonds.
- The bases are connected by hydrogen bonds.

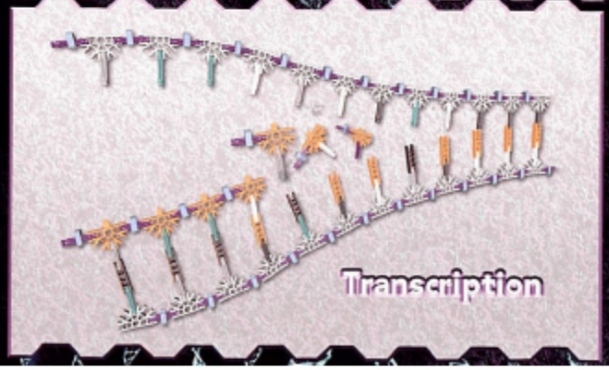



ATCG's
AUCG's
Cytosine C
Guanine G
Adenine A
Thymine T
Base pair
Sugar phosphate backbone
C Cytosine
G Guanine
A Adenine
U Uracil
replaces Thymine in RNA
DNA
Deoxyribonucleic acid
RNA
Ribonucleic acid
Nitrogenous Bases
Nitrogenous Bases

78780

DNA, Replication and Transcription

K'Nex education



DNA, Replication and Transcription

DNA *(deoxyribonucleic acid)* and mRNA *(messenger ribonucleic acid)* molecules are both made up of nucleotide units bonded together in long chains. DNA nucleotides are made up of three sub-units: deoxyribose sugars, nitrogen-containing bases and phosphate groups. Similarly, mRNA nucleotides are made up of ribose sugars, nitrogen-containing bases and phosphate groups.

Two strands *(long chains)* of DNA bond together and wrap around each other to form the classic, double helix structure discovered by Watson and Crick. The long chain of mRNA remains as a single strand after it has been transcribed from a DNA double helix.

K'NEX Education uses distinct K'NEX pieces and color-coding to represent the various molecules and bonds that form DNA and mRNA. Use the following nucleotide "Key" to determine which K'NEX pieces you will need for the DNA and mRNA models you will build as part of this series of activities.

Component parts:

DNA pieces

Deoxyribose Sugar *(use in parent strand)*

Two (2) H-Bonds

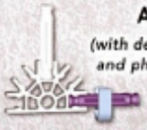
Three (3) H-Bonds

Thymine *(nitrogen-containing base)*

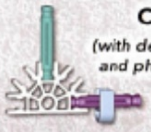
Deoxyribose Sugar
(substitute yellow Connectors for the gray Connectors to form a daughter strand)

Key:

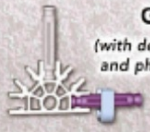
NUCLEOTIDES
(named for the nitrogen-containing base they include)



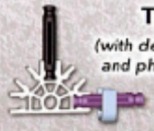
Adenine
(with deoxyribose sugar and phosphate group)



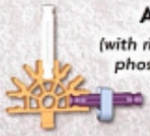
Cytosine
(with deoxyribose sugar and phosphate group)



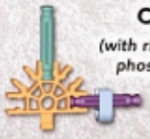
Guanine
(with deoxyribose sugar and phosphate group)



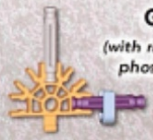
Thymine
(with deoxyribose sugar and phosphate group)



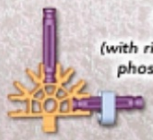
Adenine
(with ribose sugar and phosphate group)



Cytosine
(with ribose sugar and phosphate group)



Guanine
(with ribose sugar and phosphate group)



Uracil
(with ribose sugar and phosphate group)

Building a basic DNA molecule:

1. First build all the nucleotides you will need *(follow the "Key" on page 5)*.

2. Then connect them *(as shown)* to make a flat model of a basic DNA molecule.

3. When it's complete you can twist the DNA molecule into a double helix by following the instructions on the next few pages.


This is the basic DNA molecule.
Key: Nucleotides
7
7
5
5
7
5

Form the DNA molecule into a double helix:

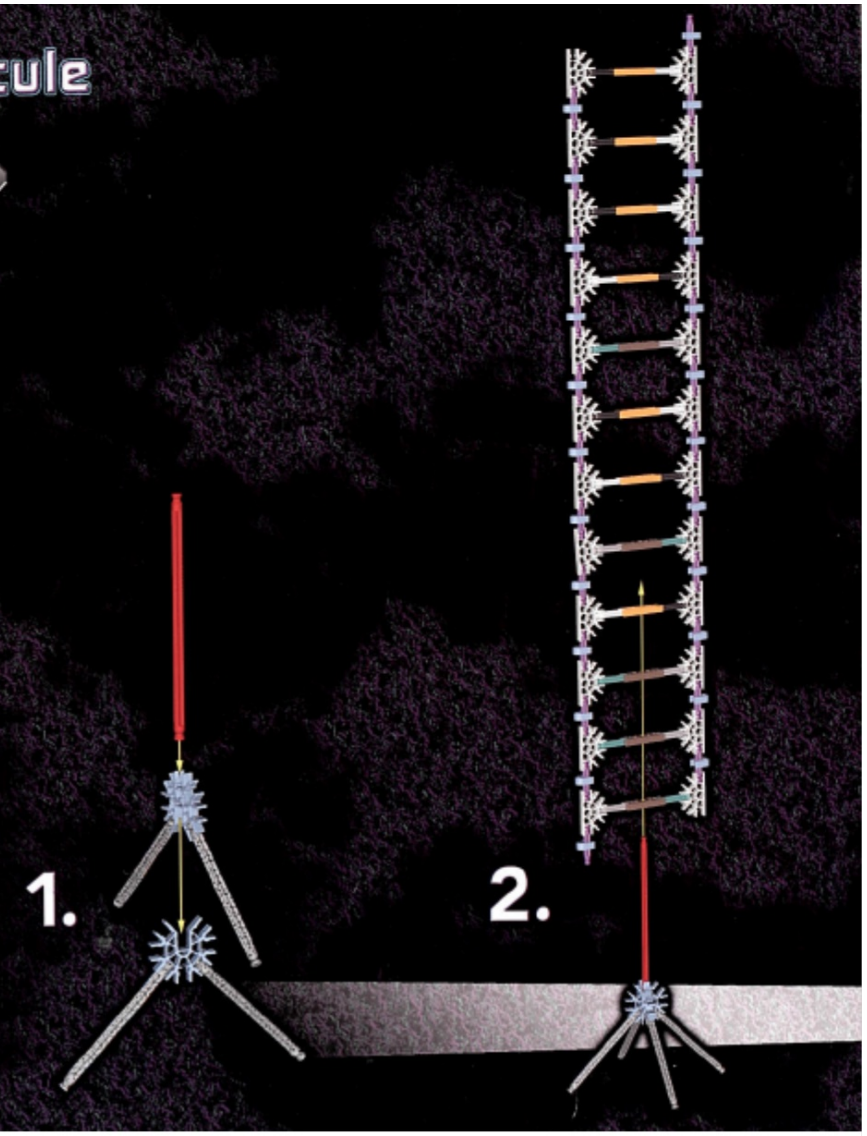
1. Build a display stand with one red Rod on it to start. Make sure the 2 light blue Connectors "click" when you put them together.

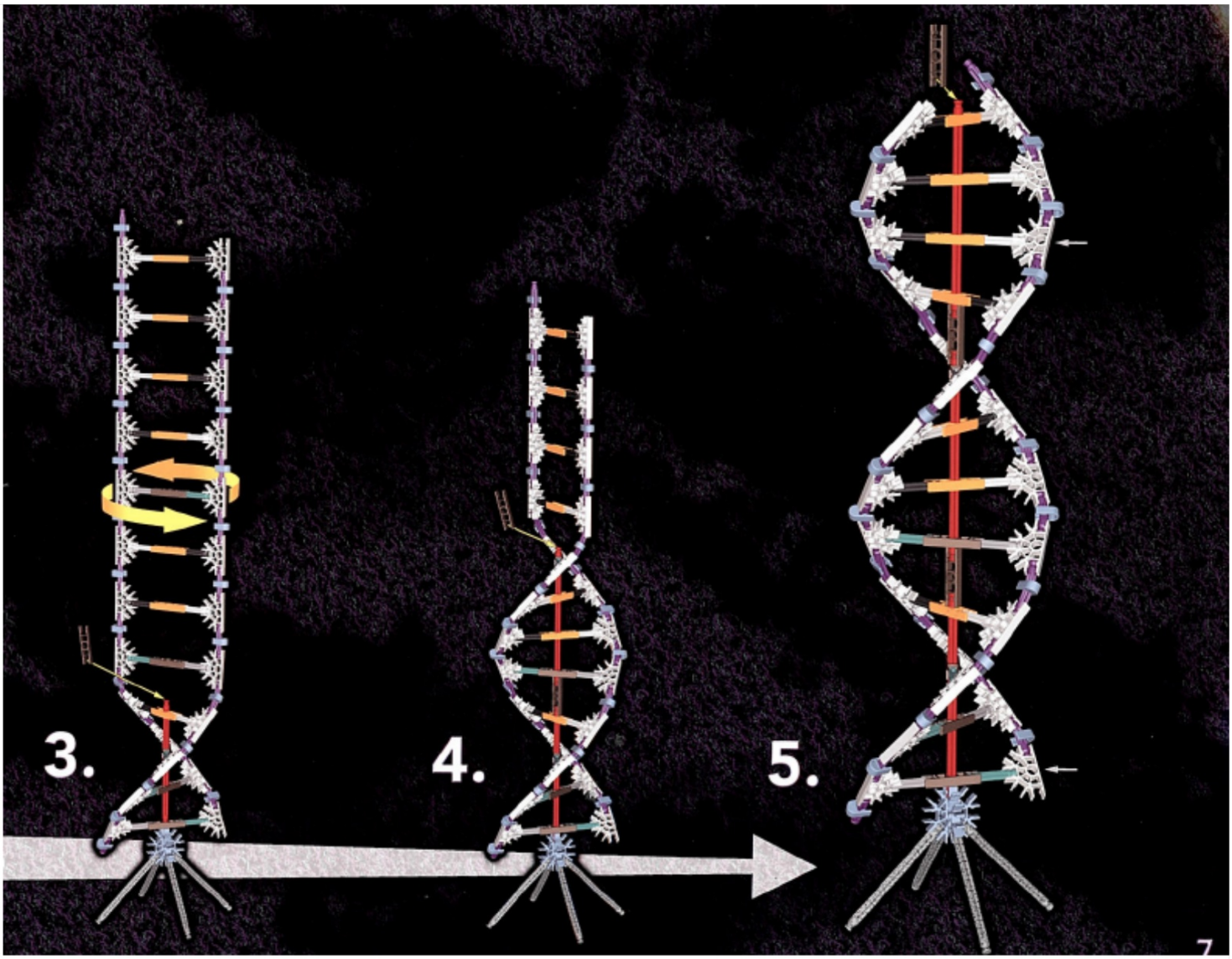
2. Rotate all of the orange and brown *(H-bonds)* Connectors so that the holes point down to align with the red Rod on the display stand.

3. Push the flat DNA molecule down as you thread the first 4 middle Connectors *(3 brown, 1 orange)* over the red Rod. Twist the DNA molecule as you push it down over the red Rod *(as shown)*. Add one brown Connector to hold the first 4 middle Connectors in the twisted position.

4. Repeat Step 3, using a second red Rod and brown Connector to hold the next 4 middle Connectors in the twisted position.

5. Repeat Step 3 again, using a third red Rod and brown Connector to complete the double helix on a stand.




3.
4.
5.

Kickoff:

Write out the complementary DNA sequence to the following gene:

5' 3'
G T C A C C T G A A T G C

8.3 DNA Replication

KEY CONCEPT

DNA replication copies the genetic information of a cell.

DNA aka:

deoxyribonucleic acid

twisted ladder

genes

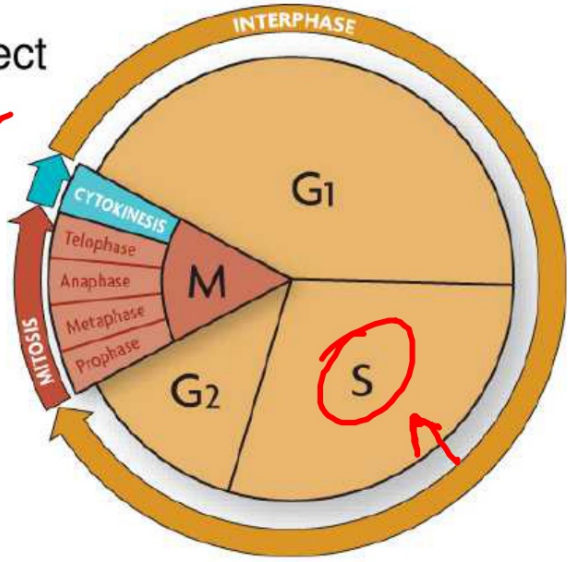
double helix

genetic code

8.3 DNA Replication

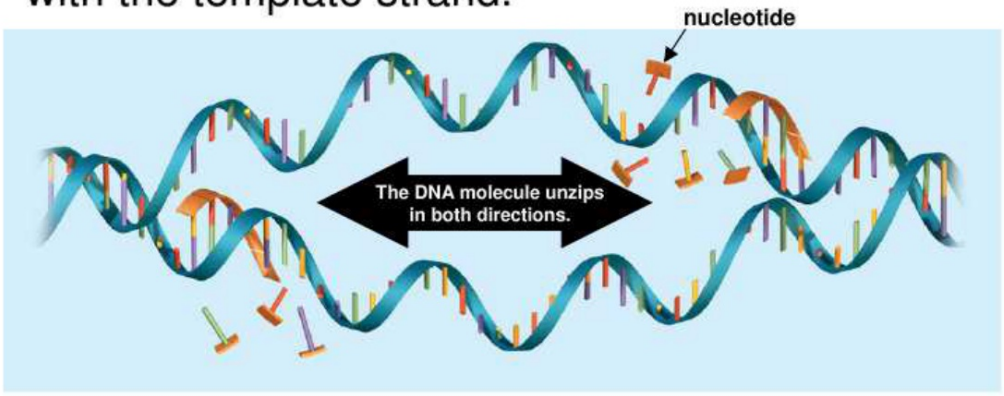
Replication copies the genetic information.

- A single strand of DNA serves as a template for a new strand.
- The rules of base pairing direct replication. A-T, G-C
- DNA is replicated during the S (synthesis) stage of the cell cycle.
- Each ~~body~~ somatic cell gets a complete set of identical DNA.



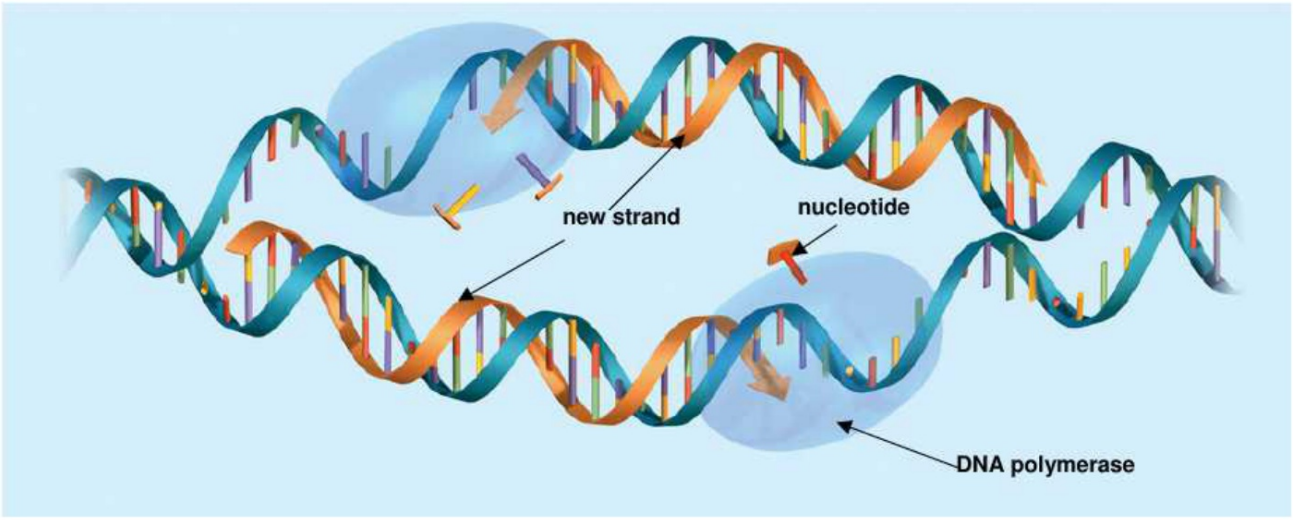
8.3 DNA Replication

- Enzymes
- **Proteins carry out the process of replication.**
  - DNA serves only as a template.
  - Enzymes and other proteins do the actual work of replication.
    - Enzymes unzip the double helix. — DNA helicase
    - Free-floating nucleotides form hydrogen bonds with the template strand.



8.3 DNA Replication

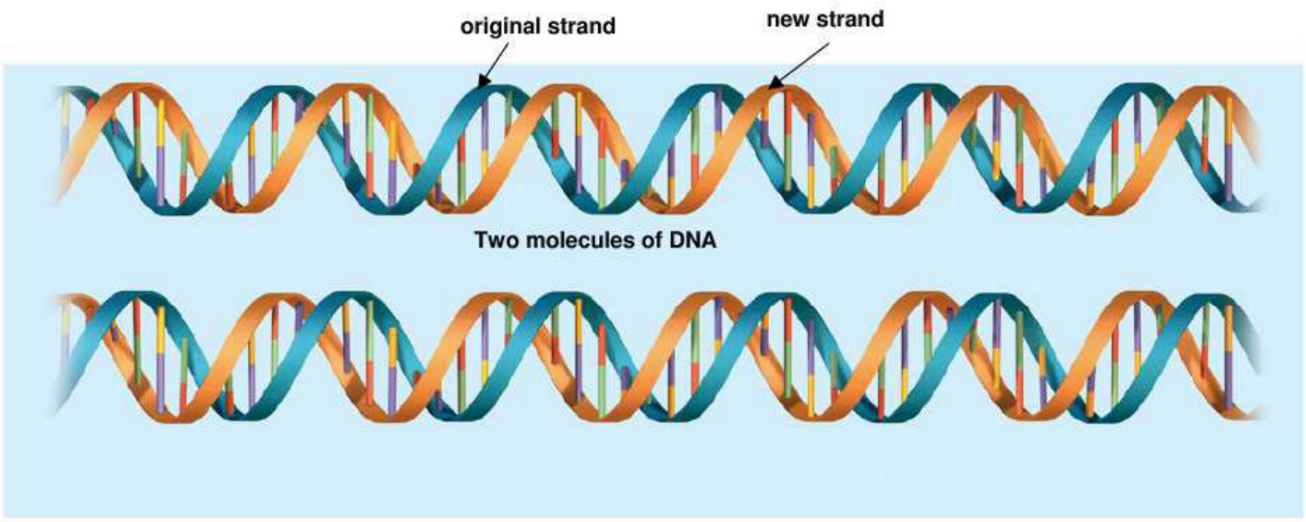
- DNA polymerase enzymes bond the nucleotides together to form the double helix.
- Polymerase enzymes form covalent bonds between nucleotides in the new strand.



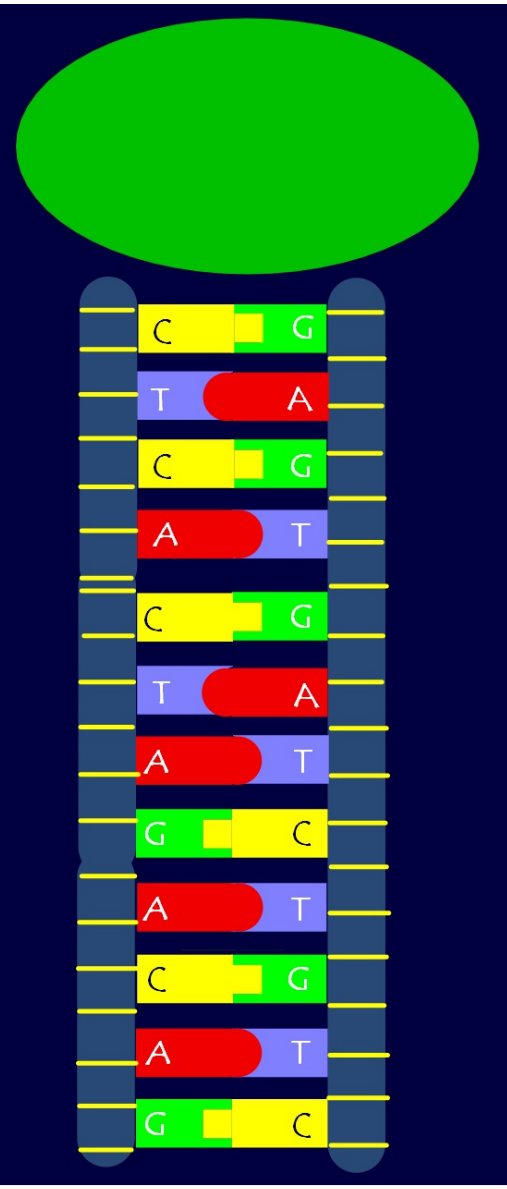
8.3 DNA Replication

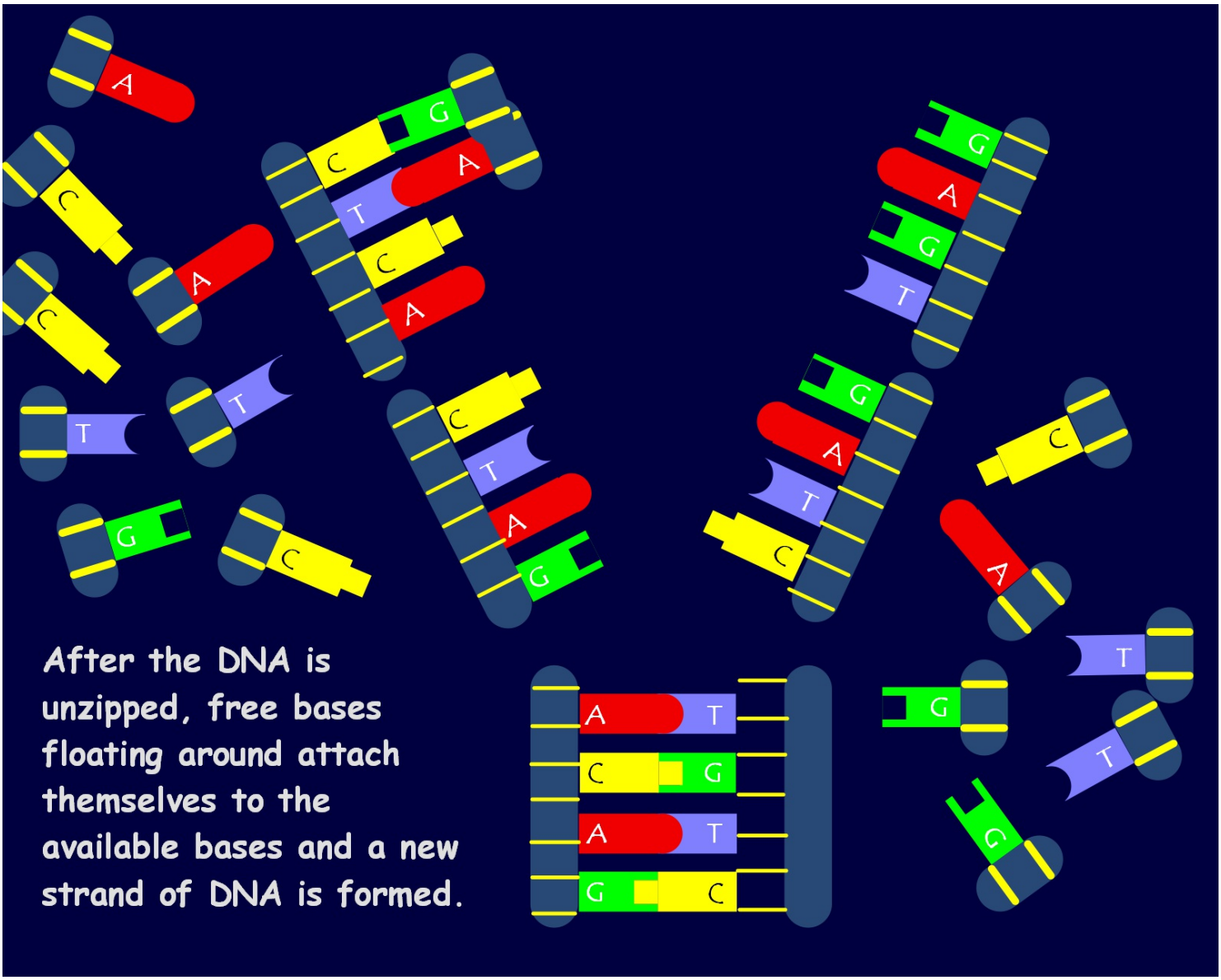
Semiconservative replication –

- Two new molecules of DNA are formed, each with an original strand and a newly formed strand.
- DNA replication is semiconservative.



During interphase, the chromosomes in a nucleus duplicate. How? An enzyme attaches itself to the DNA strand and it literally unzips the DNA strand.



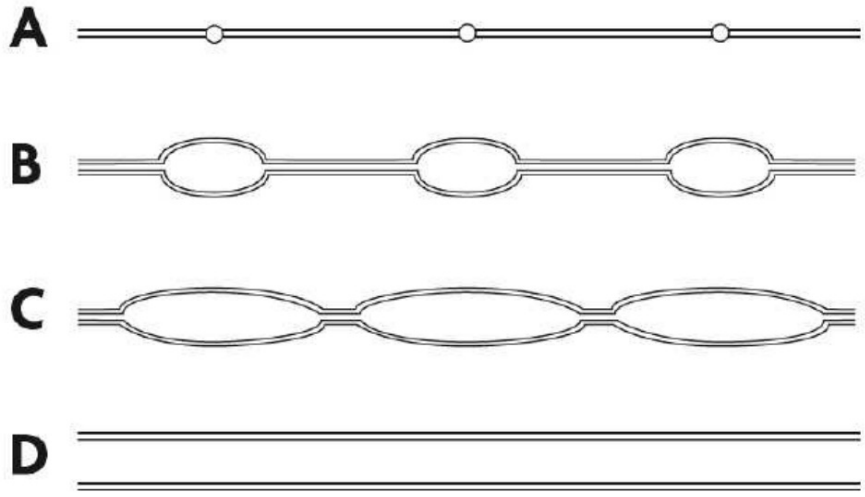

After the DNA is unzipped, free bases floating around attach themselves to the available bases and a new strand of DNA is formed.

8.3 DNA Replication

Replication is fast and accurate.

- DNA replication starts at many points in eukaryotic chromosomes.

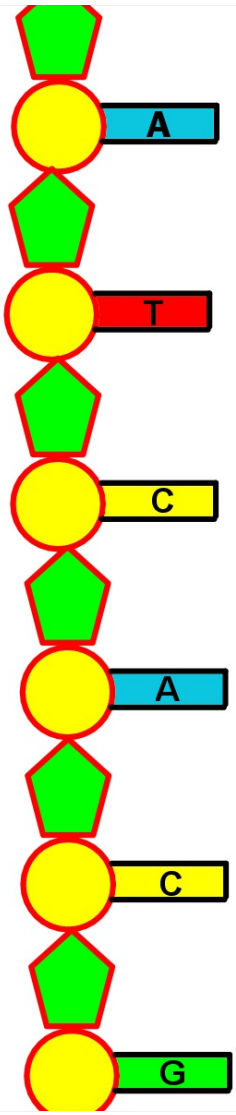
50 bp



There are many origins of replication in eukaryotic chromosomes.

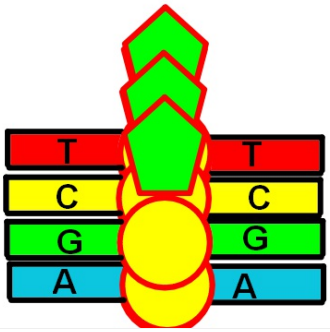
- DNA polymerases can find and correct errors.

DNA Replication



Phosphate

Sugar



DNA Replication

match the base with its complement

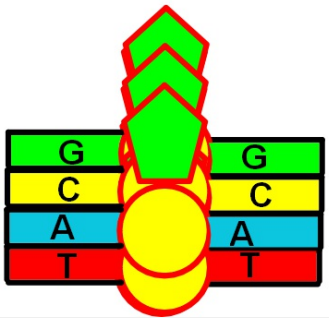
A T C C G A

A T C G

DNA Replication

G A C T CC A G T

A T C G


G
C
A
T
G
C
A
T

Kickoff:
What are the three components of central dogma?

Kickoff: Translate the amino acid sequence

Plant species A	DNA base sequence	AAC	CCA	AGT	GGA
	mRNA base sequence	UUG	GGU	UCA	CCU
	amino acid sequence	_____	_____	_____	_____

Universal Genetic Code Chart
Messenger RNA Codons and the Amino Acids for Which They Code

FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU, UUC: PHE UUA, UUG: LEU	UCU, UCC, UCA, UCG: SER	UAU, UAC: TYR UAA, UAG: STOP	UGU, UGC: CYS UGA: STOP UGG: TRP	U C A G
C	CUU, CUC, CUA, CUG: LEU	CCU, CCC, CCA, CCG: PRO	CAU, CAC: HIS CAA, CAG: GLN	CGU, CGC, CGA, CGG: ARG	U C A G
A	AUU, AUC, AUA: ILE AUG: MET or START	ACU, ACC, ACA, ACG: THR	AAU, AAC: ASN AAA, AAG: LYS	AGU, AGC: SER AGA, AGG: ARG	U C A G
G	GUU, GUC, GUA, GUG: VAL	GCU, GCC, GCA, GCG: ALA	GAU, GAC: ASP GAA, GAG: GLU	GGU, GGC, GGA, GGG: GLY	U C A G

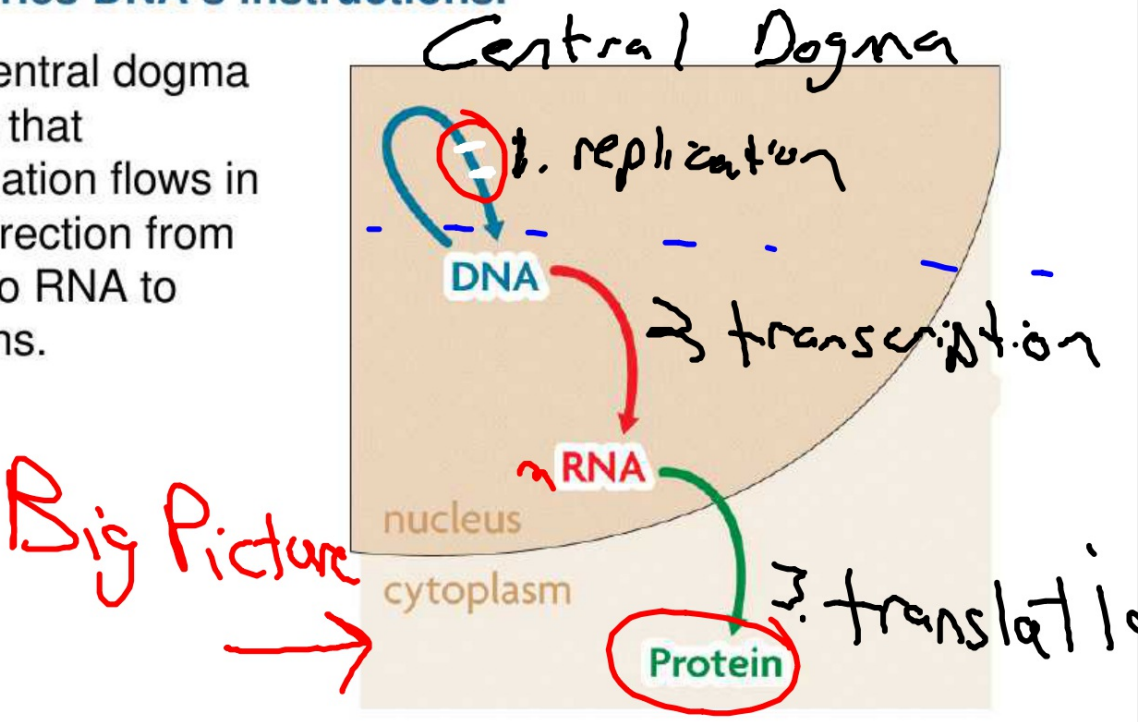
8.4 Transcription

KEY CONCEPT

Transcription converts a gene into a single-stranded RNA molecule.

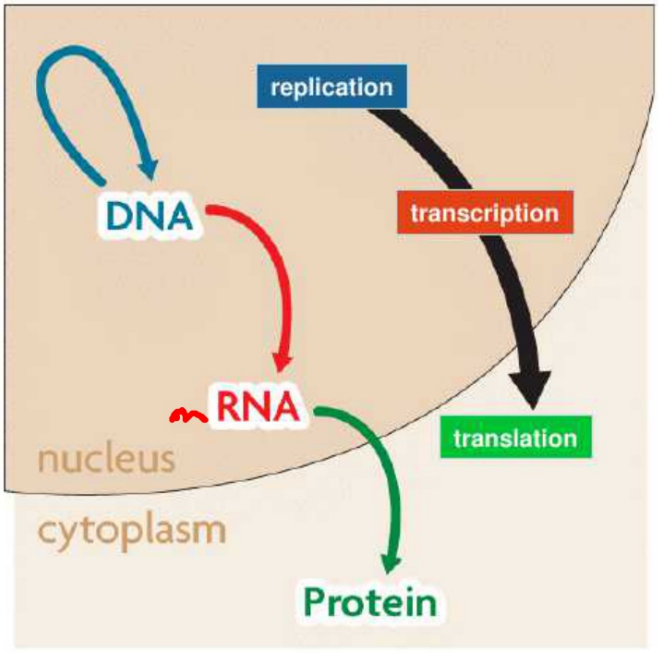
8.4 Transcription

- **RNA carries DNA's instructions.**
  - The central dogma states that information flows in one direction from DNA to RNA to proteins.



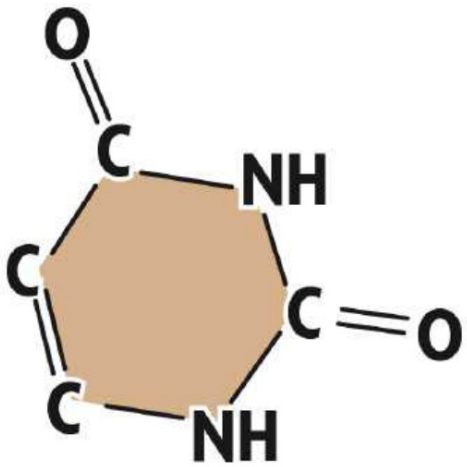
8.4 Transcription

- The central dogma includes three processes.
  1. – Replication
  2. – Transcription
  3. – Translation
- RNA is a link between DNA and proteins.



8.4 Transcription

- RNA differs from DNA in three major ways.
  - RNA has a ribose sugar.
  - RNA has uracil instead of thymine. (U instead of T)
  - RNA is a single-stranded structure.



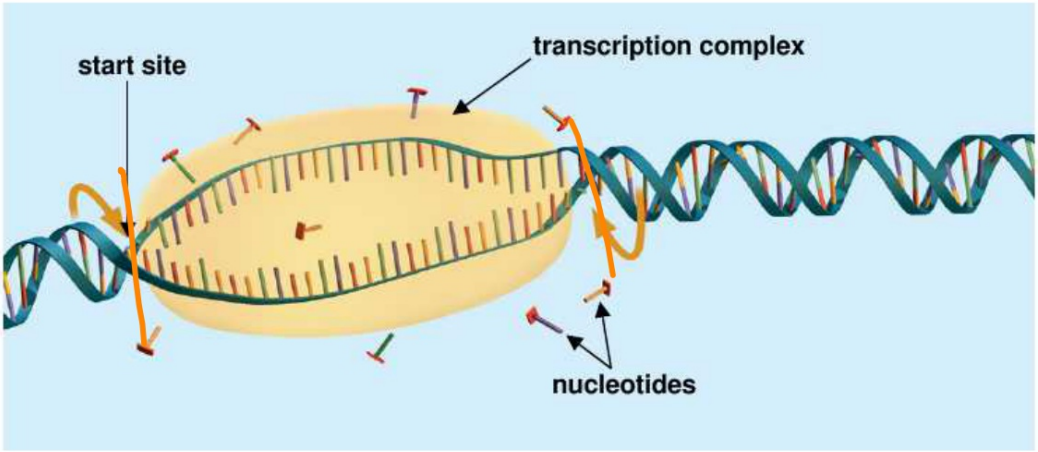
8.4 Transcription

- **Transcription makes three types of RNA.**
  - Transcription copies DNA to make a strand of RNA.

- messenger RNA (mRNA)

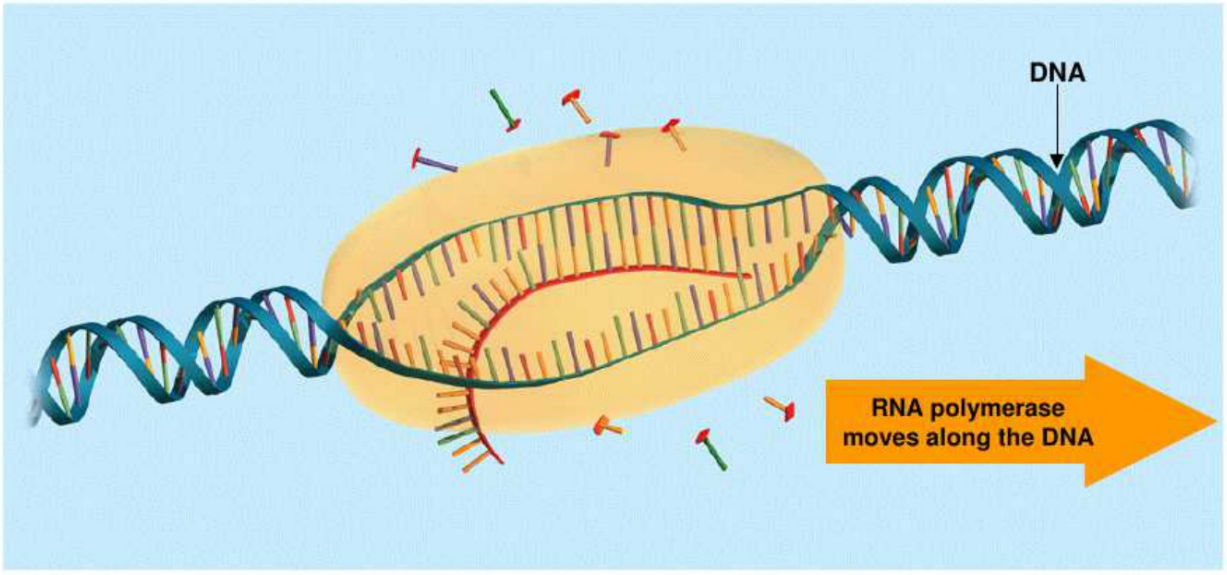
8.4 Transcription

- Transcription is catalyzed by RNA polymerase.
  - RNA polymerase and other proteins form a transcription complex.
  - The transcription complex recognizes the start of a gene and unwinds a segment of it.



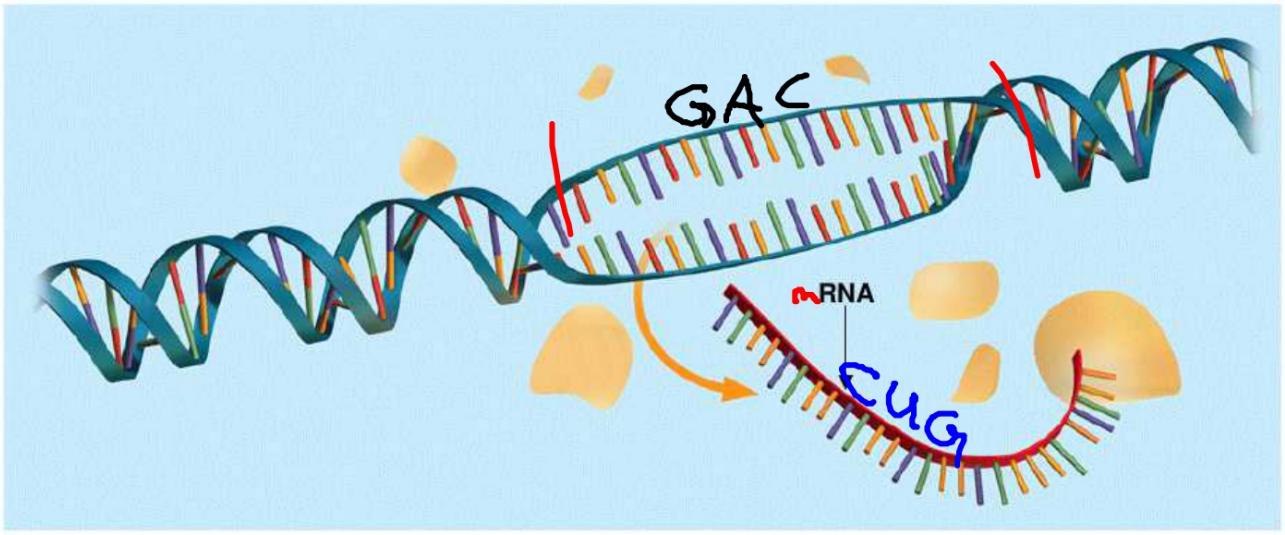
8.4 Transcription

– Nucleotides pair with one strand of the DNA.
– RNA polymerase bonds the nucleotides together.
– The DNA helix winds again as the gene is transcribed.



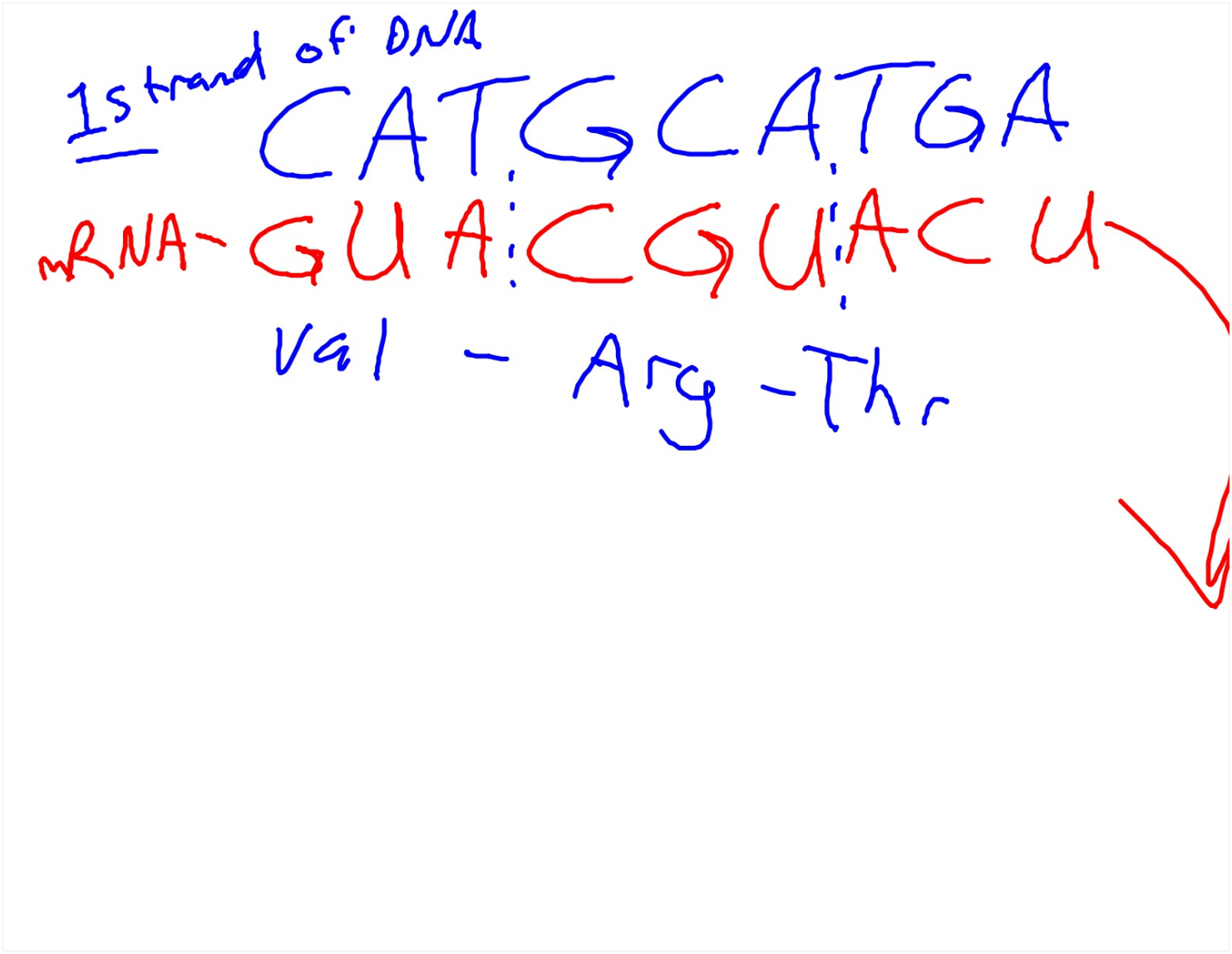
8.4 Transcription

– The mRNA strand detaches from the DNA once the gene is transcribed.



8.4 Transcription

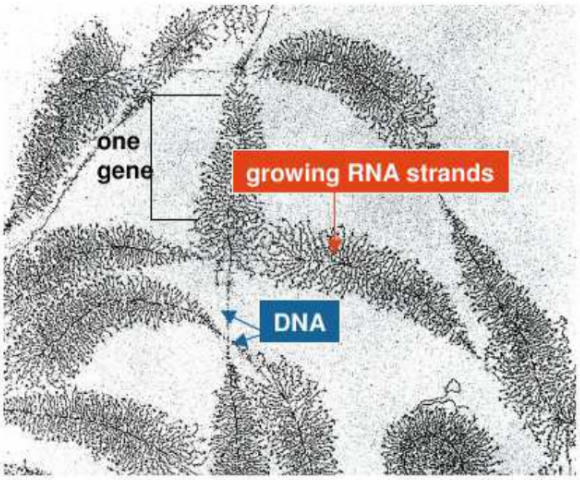
- Transcription makes three types of RNA.
  - Messenger RNA (mRNA) carries the message that will be translated to form a protein.
  - Ribosomal RNA (rRNA) forms part of ribosomes where proteins are made.
  - Transfer RNA (tRNA) brings amino acids from the cytoplasm to a ribosome.


1st strand of DNA
CATGCATGA
mRNA- GUA:CGU:ACU
Val - Arg - Thr

8.4 Transcription

The transcription process is similar to replication.

- Transcription and replication both involve complex enzymes and complementary base pairing.
- The two processes have different end results.
  - Replication copies all the DNA; transcription copies a gene.
  - Replication makes one copy; transcription can make many copies.



Kickoff: Translate the amino acid sequence

Plant species A	DNA base sequence	AAC	CCA	AGT	GGA
	↓ transcription				
	mRNA base sequence	UUG	GGU	UCA	CCU
	↓ translate				
	amino acid sequence	leu	gly	ser	pro

Universal Genetic Code Chart
Messenger RNA Codons and the Amino Acids for Which They Code

FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU, UUC: PHE	UCU, UCC, UCA, UCG: SER	UAU, UAC: TYR	UGU, UGC: CYS	U C A G
	UUA, UUG: LEU		UAA, UAG: STOP	UGA: STOP; UGG: TRP	
C	CUU, CUC, CUA, CUG: LEU	CCU, CCC, CCA, CCG: PRO	CAU, CAC: HIS; CAA, CAG: GLN	CGU, CGC, CGA, CGG: ARG	U C A G
A	AUU, AUC, AUA: ILE	ACU, ACC, ACA, ACG: THR	AAU, AAC: ASN; AAA, AAG: LYS	AGU, AGC: SER; AGA, AGG: ARG	U C A G
	AUG: MET or START				
G	GUU, GUC, GUA, GUG: VAL	GCU, GCC, GCA, GCG: ALA	GAU, GAC: ASP; GAA, GAG: GLU	GGU, GGC, GGA, GGG: GLY	U C A G

SPI 4.3: Recognize the interactions between DN and RNA during protein synthesis.

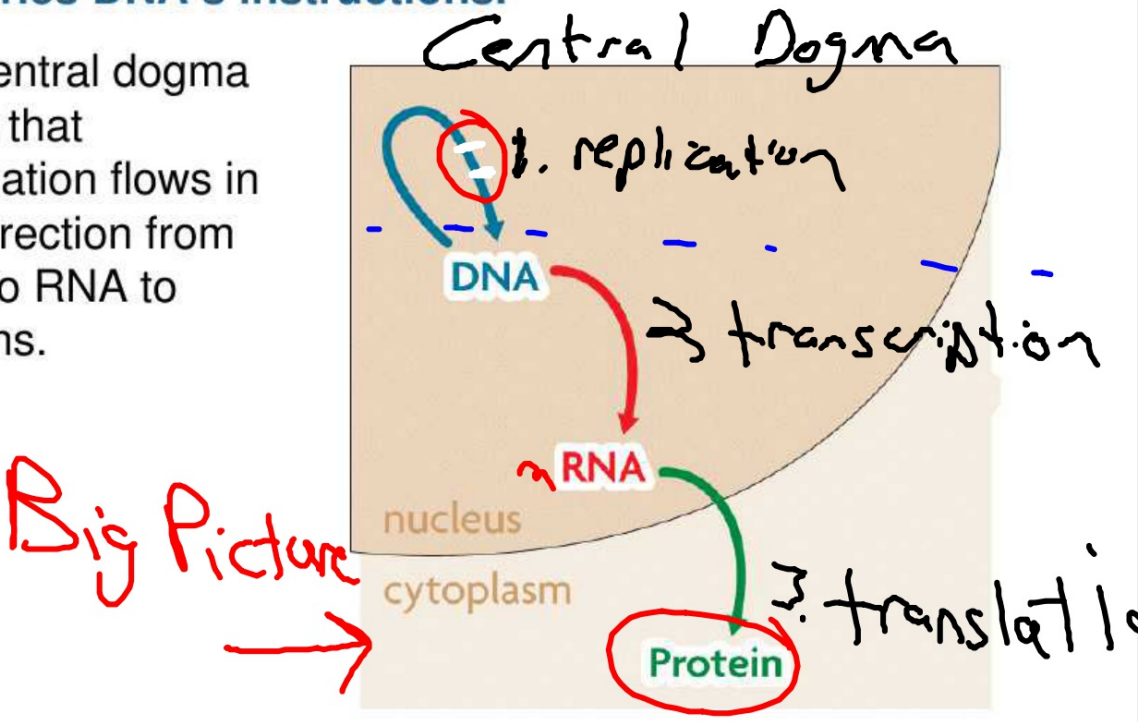
8.5 Translation

KEY CONCEPT

Translation converts an mRNA message into a polypeptide, or protein.

8.4 Transcription

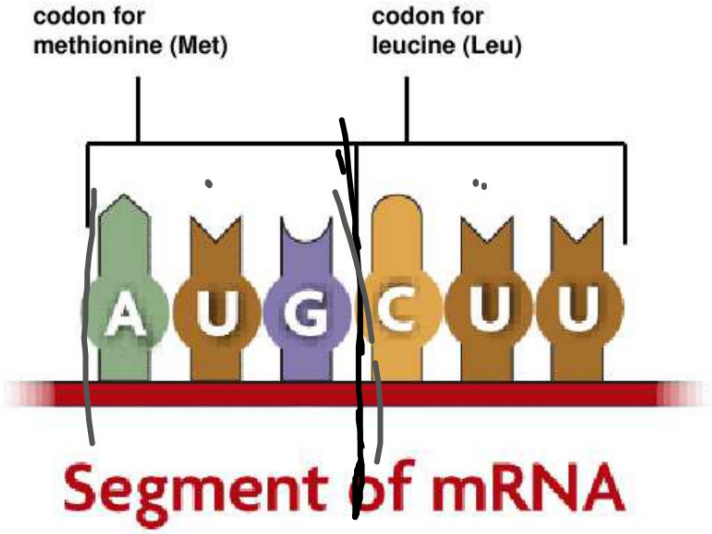
- **RNA carries DNA's instructions.**
  - The central dogma states that information flows in one direction from DNA to RNA to proteins.



8.5 Translation

Amino acids are coded by mRNA base sequences.

- Translation converts mRNA messages into polypeptides.
- A codon is a sequence of three nucleotides that codes for an amino acid.



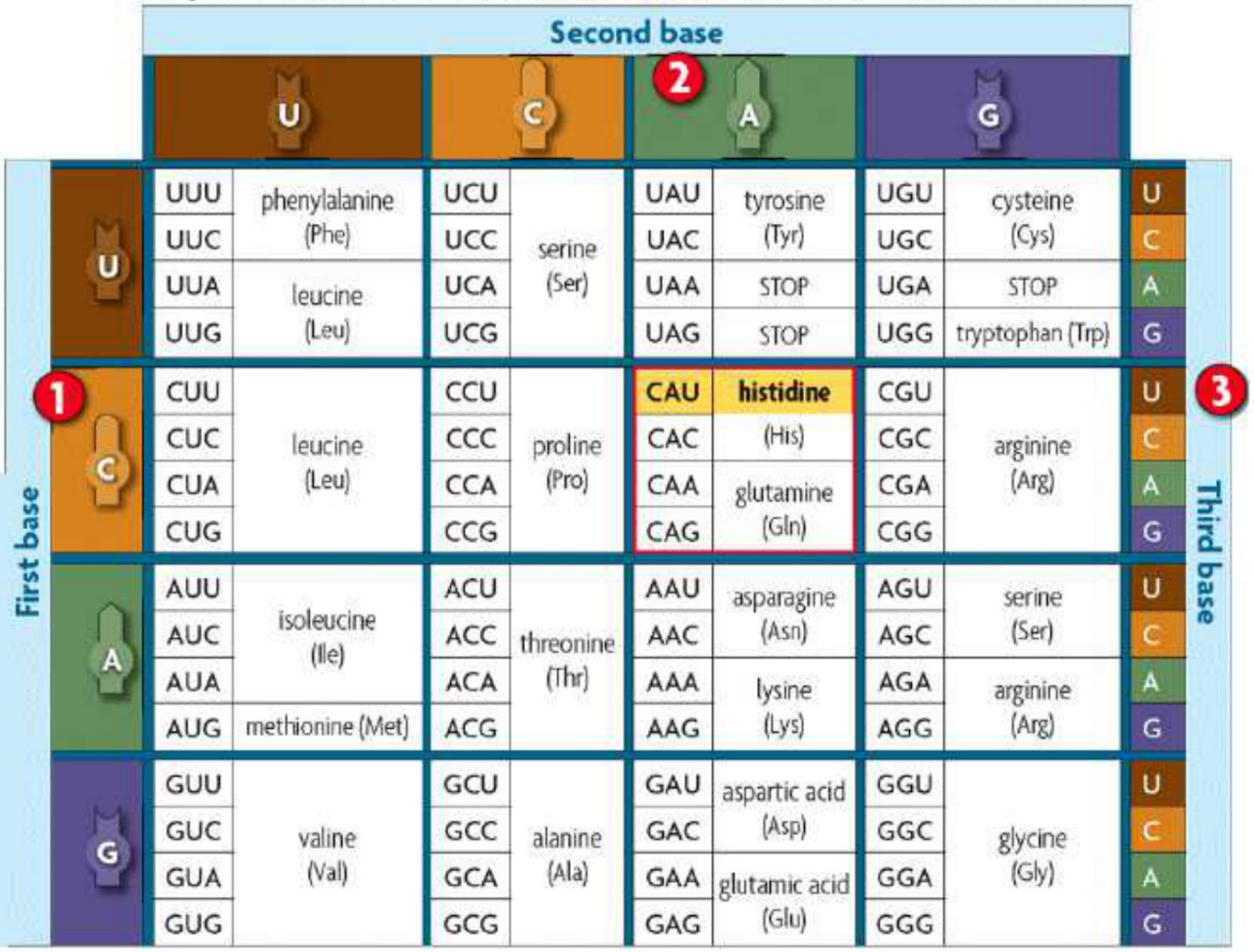
stop
ns
tart
n,
s for
onine

first base, C,
t column.

second base,
top row. Find
where these
sect.

third base,
right col-
U codes
ine, abbre-
His.

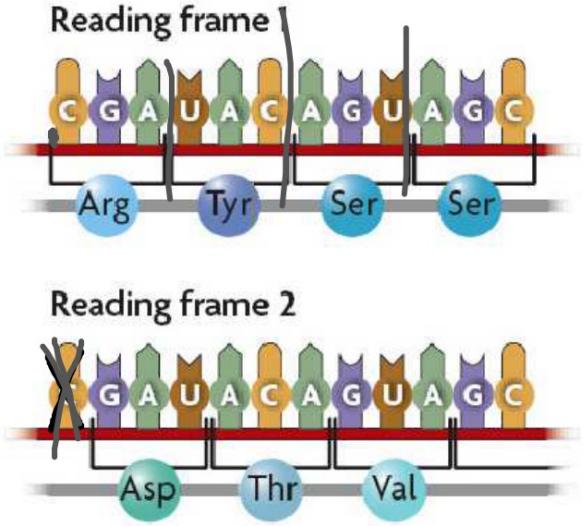
The genetic code matches each RNA **codon** with its amino acid or function.



First base	Second base U		Second base C		Second base A		Second base G		Third base
U	UUU	phenylalanine (Phe)	UCU	serine (Ser)	UAU	tyrosine (Tyr)	UGU	cysteine (Cys)	U
	UUC		UCC		UAC		UGC		C
	UUA	leucine (Leu)	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	tryptophan (Trp)	G
C	CUU	leucine (Leu)	CCU	proline (Pro)	CAU	histidine (His)	CGU	arginine (Arg)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	glutamine (Gln)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	isoleucine (Ile)	ACU	threonine (Thr)	AAU	asparagine (Asn)	AGU	serine (Ser)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lysine (Lys)	AGA	arginine (Arg)	A
	AUG	methionine (Met)	ACG		AAG		AGG		G
G	GUU	valine (Val)	GCU	alanine (Ala)	GAU	aspartic acid (Asp)	GGU	glycine (Gly)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glutamic acid (Glu)	GGA		A
	GUG		GCG		GAG		GGG		G

8.5 Translation

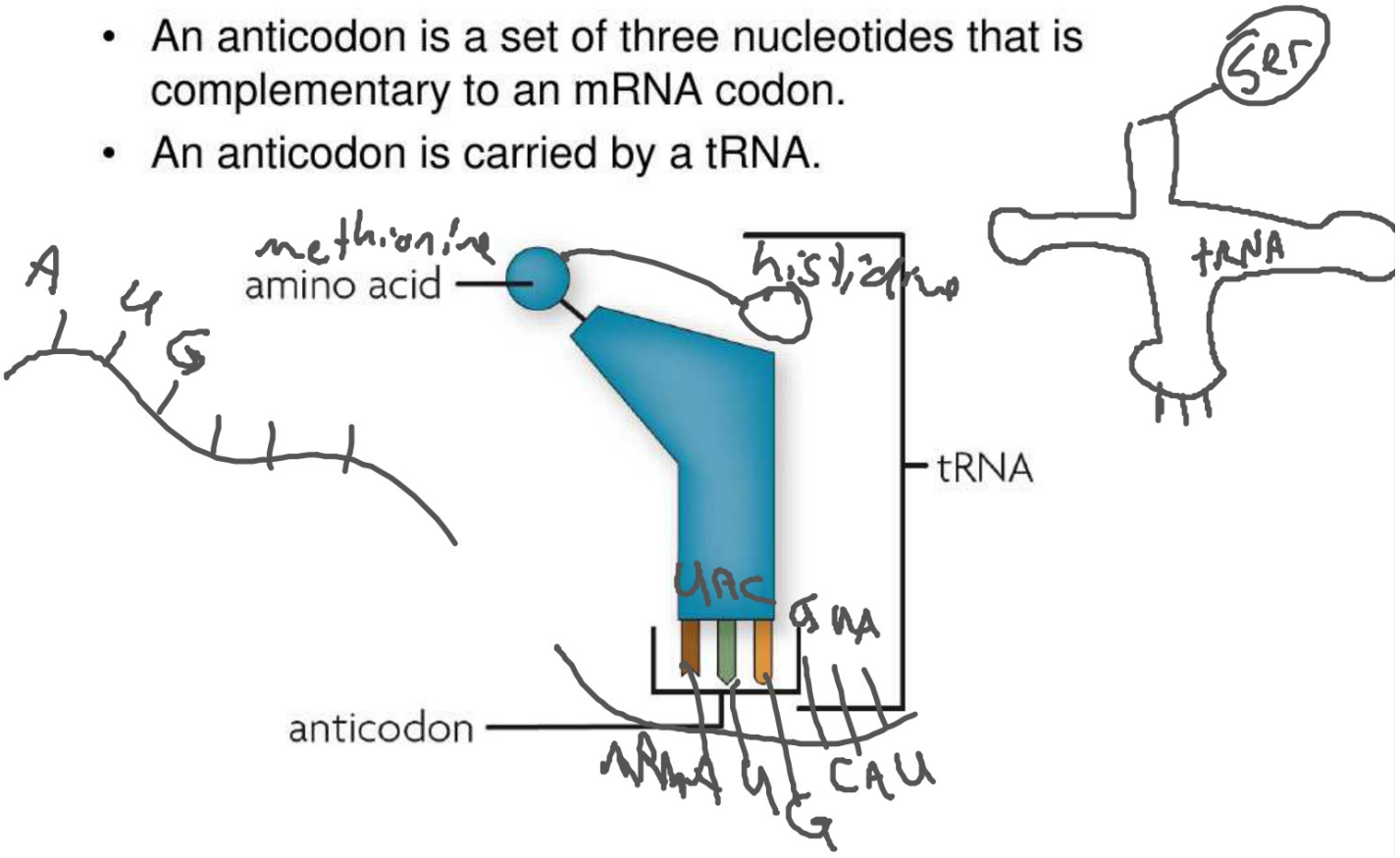
- A change in the order in which codons are read changes the resulting protein.

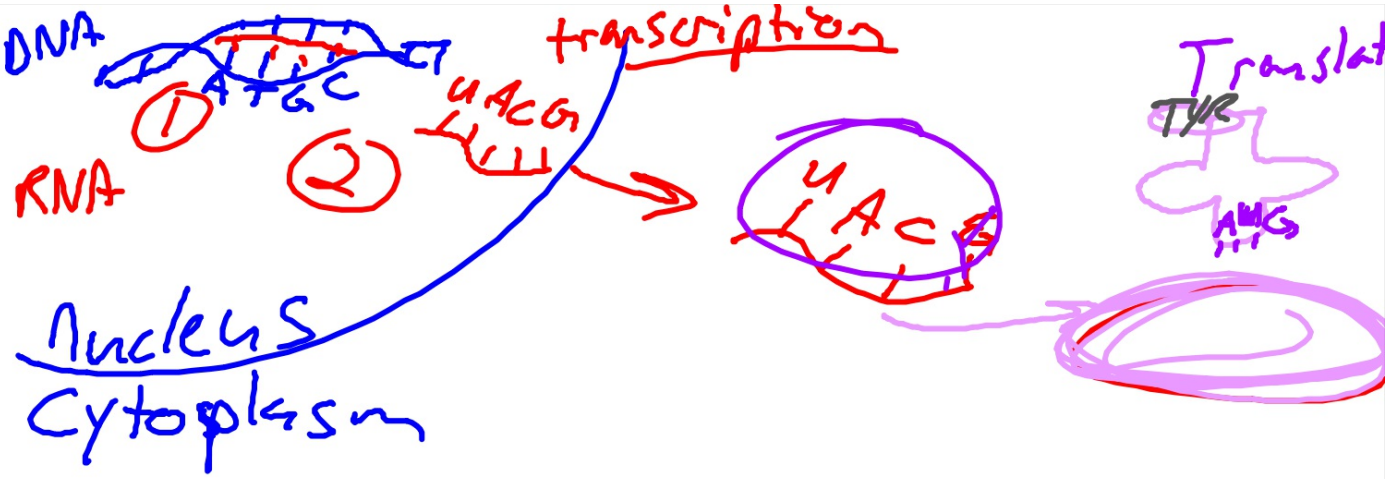


- Regardless of the organism, codons code for the same amino acid.

8.5 Translation

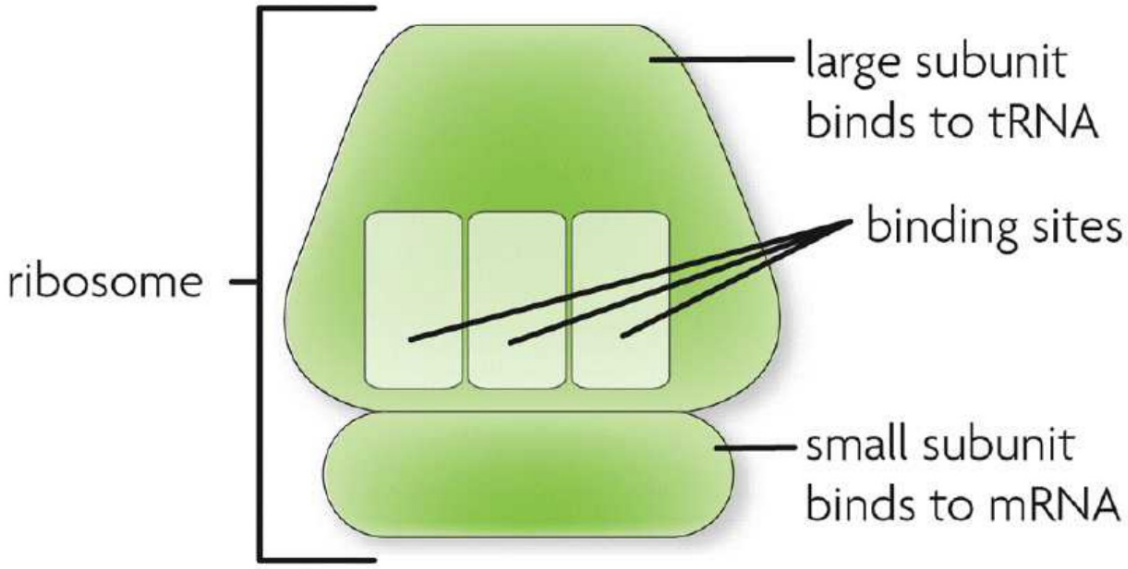
- **Amino acids are linked to become a protein.**
  - An anticodon is a set of three nucleotides that is complementary to an mRNA codon.
  - An anticodon is carried by a tRNA.




DNA
ATGC
1
2
RNA
UACG
transcription
Nucleus
Cytoplasm
UACG
Translat
TYR
AUG

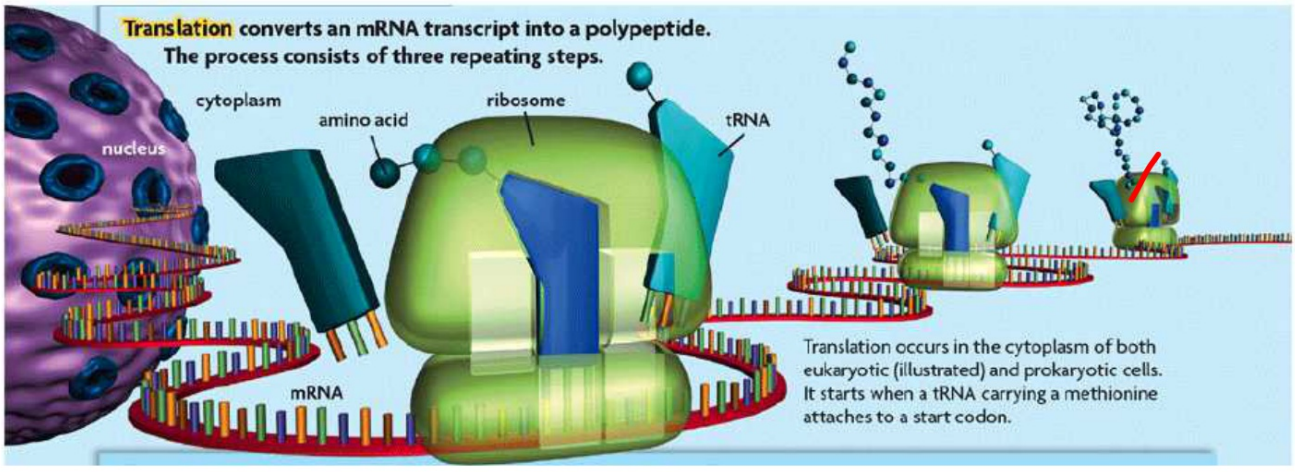
8.5 Translation

- Ribosomes consist of two subunits.
  - The large subunit has three binding sites for tRNA.
  - The small subunit binds to mRNA.



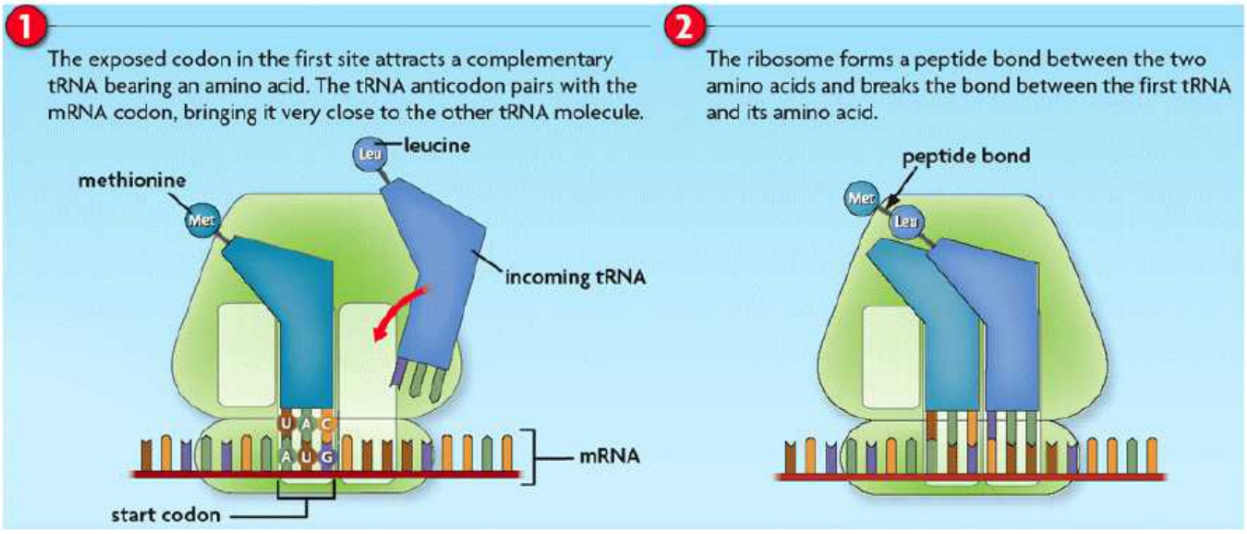
8.5 Translation

- For translation to begin, tRNA binds to a start codon and signals the ribosome to assemble.
  - A complementary tRNA molecule binds to the exposed codon, bringing its amino acid close to the first amino acid.



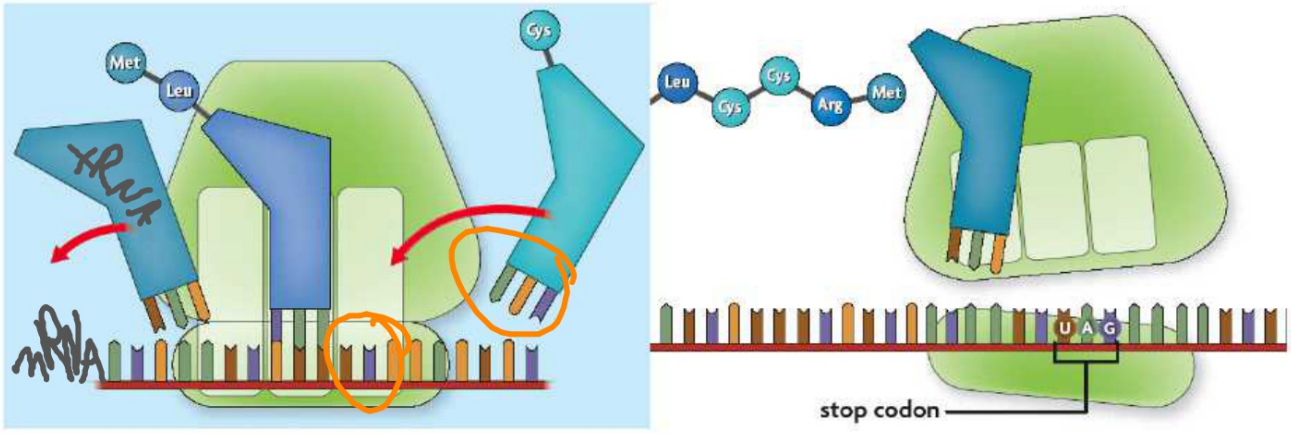
8.5 Translation

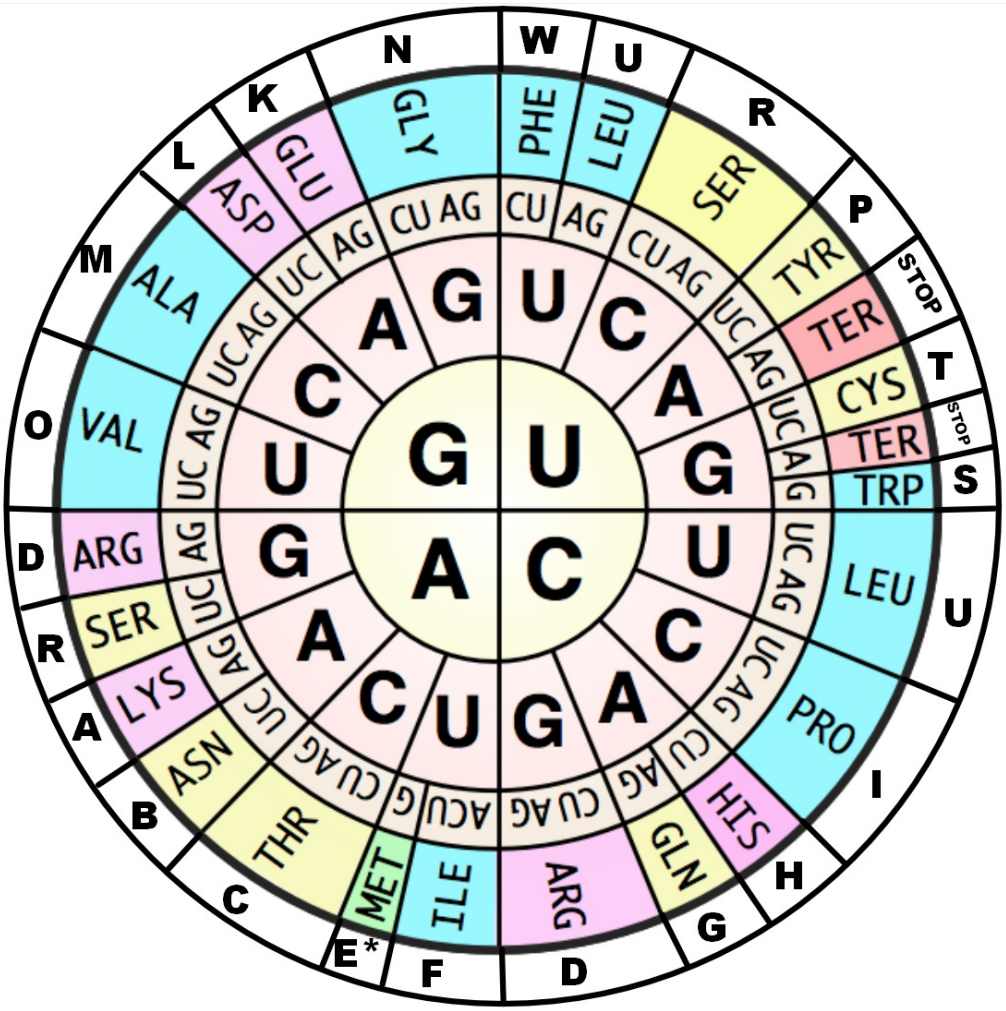
- The ribosome helps form a polypeptide bond between the amino acids.
- The ribosome pulls the mRNA strand the length of one codon.



8.5 Translation

- The now empty tRNA molecule exits the ribosome.
- A complementary tRNA molecule binds to the next exposed codon.
- Once the stop codon is reached, the ribosome releases the protein and disassembles.




G U C A
U C A G
PHE LEU SER TYR
CU AG
GLY GLU ASP ALA
CU AG
TER CYS TER TRP
UC A G
VAL ARG SER LYS ASN THR MET ILE ARG GLN HIS PRO LEU LEU
UC AG
STOP STOP
N W U R P T S U I H G D F E* C B A R D O M L K
A C G U
U C A G
U C A G
U C A G

Parent DNA	Replicate DNA	mRNA	tRNA	Amino Acids
5’				
A				
G				
T				
A				
T				
G				
T				
T				
G				
T				
A				
A				
G				
C				
T				
3’				