
NEW JERSEY CENTER
FOR TEACHING & LEARNING
Progressive Science Initiative®
This material is made freely available at www.njctl.org and is intended for the non-commercial use of students and teachers. It may not be used for any commercial purpose without the written permission of NJCTL.
We, at the New Jersey Education Association, are proud founders and supporters of NJCTL, an independent non-profit organization with the mission of empowering teachers to lead school improvement for the benefit of all students.
njea

NEW JERSEY CENTER
FOR TEACHING & LEARNING

Biology

Genes

www.njctl.org

Vocabulary

Click on each word below to go to the definition.

3' end
5' end
A site
anti-parallel
anticodon
central dogma
codon
daughter strand
DNA polymerase
elongation
gene
gene expression
initiation
mRNA
P site
polymerase chain reaction
parent strand
promoter
replicate
ribosome
RNA polymerase
rRNA
semi-conservative
template strand
termination
terminator sequence
transcription
translation
tRNA

Genes Unit Topics

Click on the topic to go to that section

DNA Replication

Return to Table of Contents

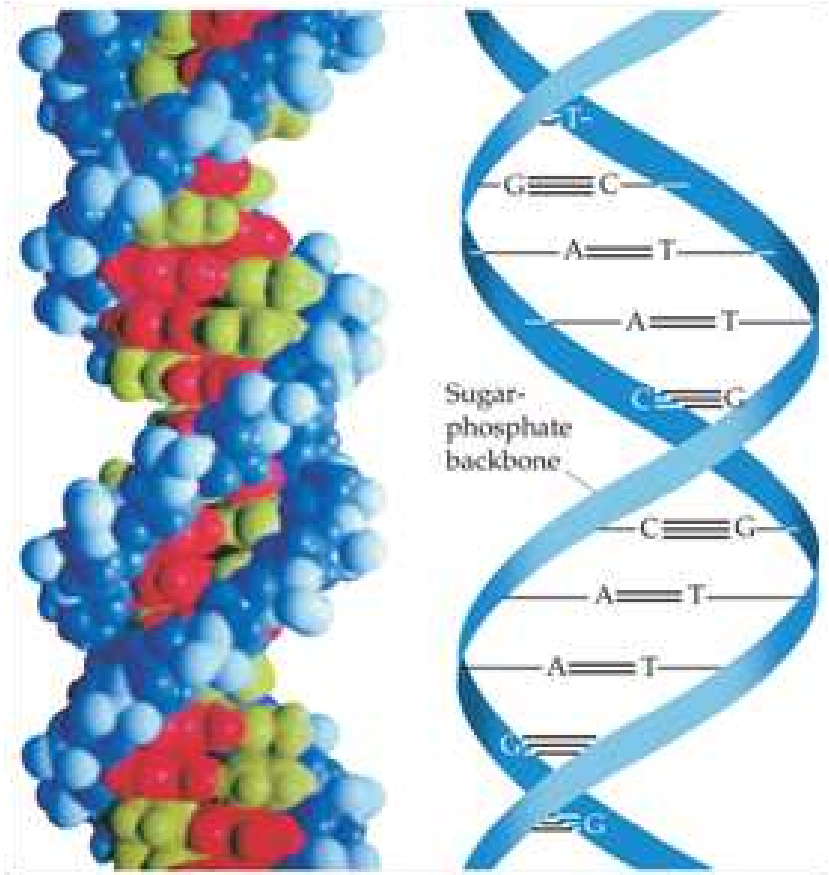
Genes

A gene is a segment of DNA needed to make a specific protein.

The complementary base pairs of DNA are:
guanine (G) with _____ (C) and _____ (A) with thymine (T) .

The nucleotides of one strand bond to matching nucleotides in a second strand, to create the double stranded helix.

DNA is a good archive for genetic information since the bases are protected on the inside of the helix.



1 What is the shape of DNA called?

- A single helix
- B
- C it has many shapes
- D

2 In DNA, adenine pairs with...

- A uracil
- B guanine
- C thymine
- D cytosine

3 In DNA, guanine pairs with...

- A uracil
- B adenine
- C thymine
- D cytosine

4 If one strand of DNA is CGGTAC, the complementary strand would be:

- A GCCTAG
- B CGGTAC
- C TAACGT
- D GCCATG

5 If one strand of DNA is AGCTGA, the complementary strand would be:

- A TCGACU
- B TCGACT
- C AGCTGA
- D AGTCGA

Replication

The functions of a cell are determined by its DNA.

Cells have to reproduce many times. In complex organisms, trillions of copies are made from one original cell.

But when cells reproduce, they must replicate (or copy) their DNA.

The structure of DNA reveals how trillions of copies of the DNA in one of your cells can be made, and be almost exactly the same each time.

Watson & Crick

Francis Crick and James Watson discovered the structure of DNA in 1953. This breakthrough was on a par with Newton's work in physics...but in our recent past.

When Watson and Crick published the structure of DNA in a short article in 1953 they stated:

"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."

The fact that there are two DNA strands that are mirror images of one another suggested how copies could be made of each DNA sequence.

Click here to see the letter Francis Crick wrote to his son about the structure of DNA

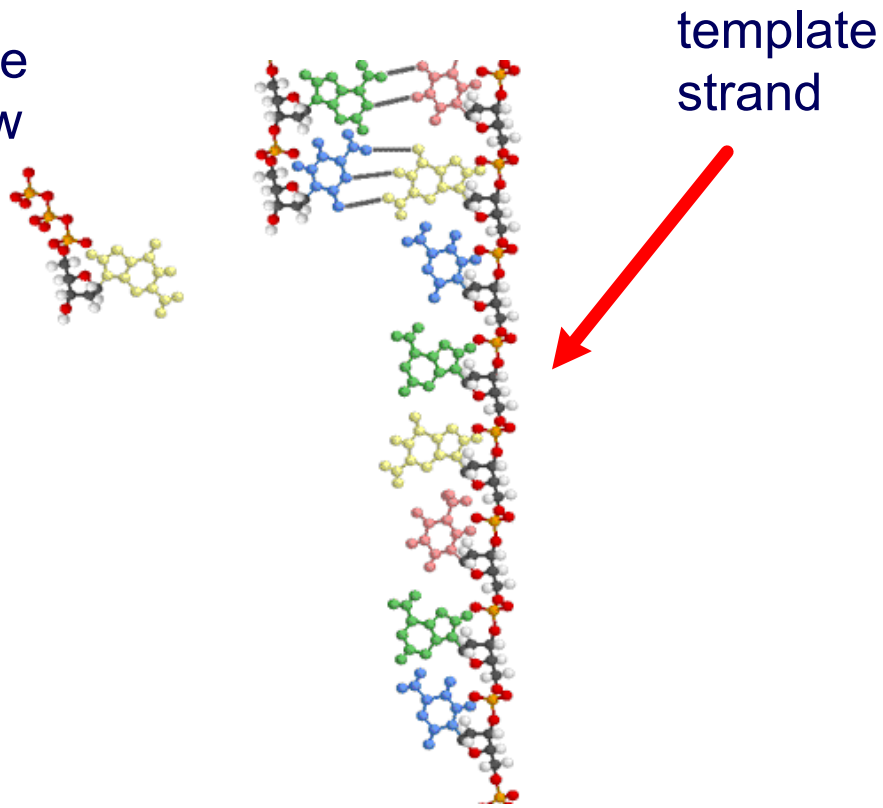
DNA Molecule as Template

Each molecule of DNA is made of a template strand and a new strand.

The template is used to make the new strand.

The template strand is also known as the parent strand since it came from the original DNA molecule.

The new strand is also known as the daughter strand.

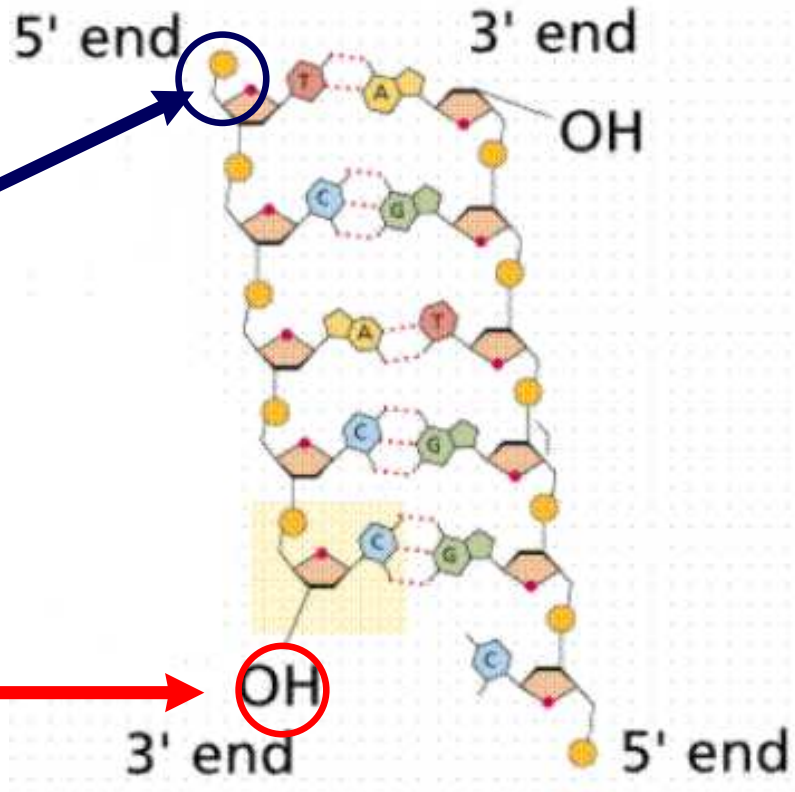


DNA is Anti-Parallel

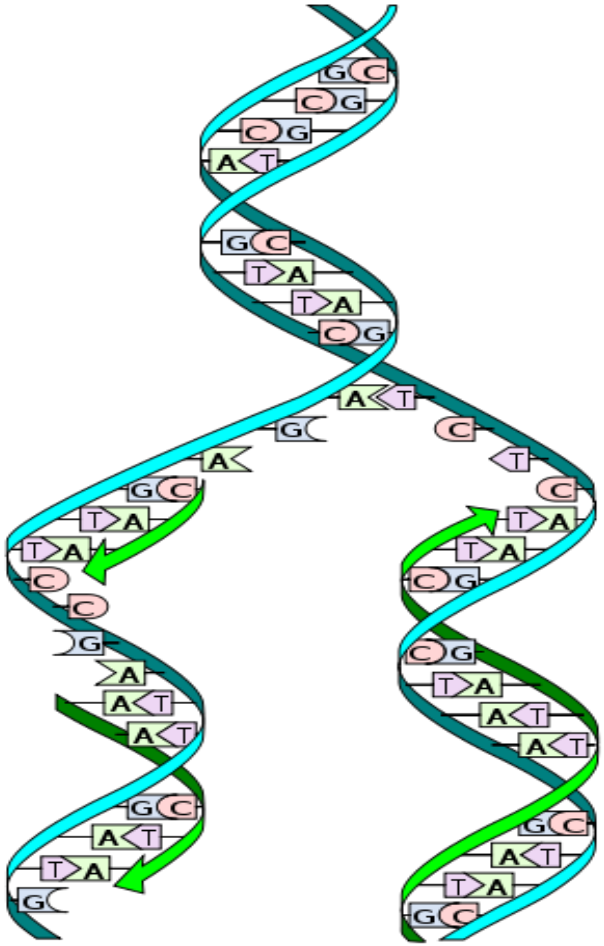
Each strand has two ends: a 5' end and a 3' end. The two strands of DNA always run in opposite directions. They are said to be anti-parallel to each other.

The 5' end has a phosphate group at the end.

The 3' end has an -OH group at the end.



Separation of Strands



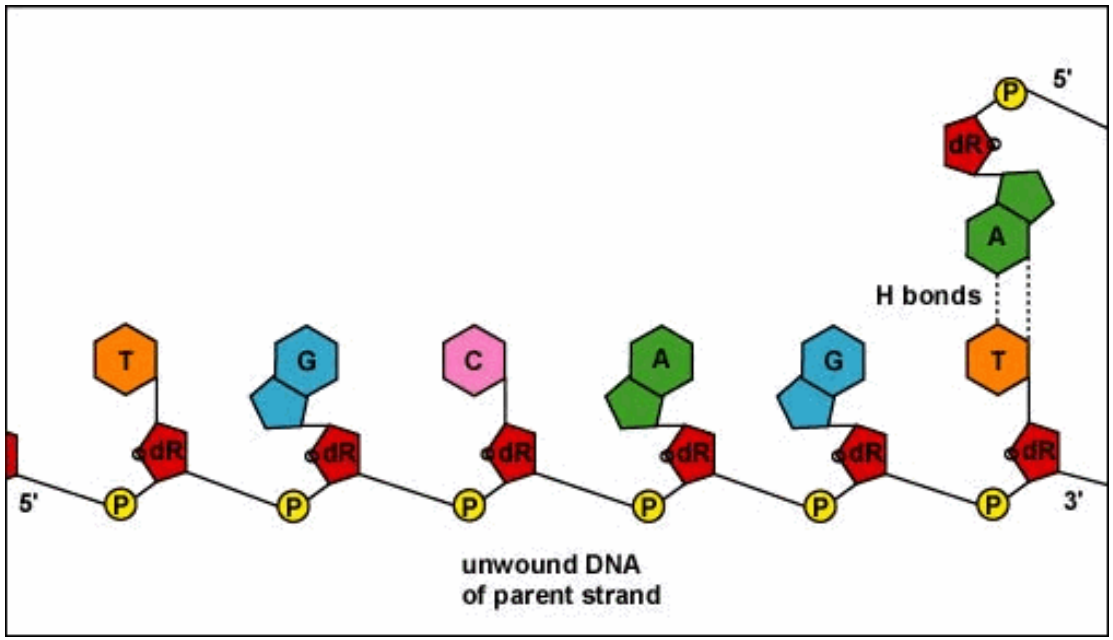
The template strands of the DNA molecule separate and the new strands are made on the inside.

The result of this process is 2 new DNA molecules each having an old template strand and new strand. This is called semi-conservative because it "conserves" some of the old DNA in each copy.

Click here to see an animation of the mechanism of replication

Adding New Nucleotides

Nucleotides can only be added to the -OH end (3`), not the 5`so all new strands are made in the 5' - 3' direction.



Replication Practice

3' ATCGGGTTAACGCGTAAA 5' *template strand*

5' _____ *3' new strand*

What is the sequence of the new strand?

3' GGTTACTAATCGAGCCCCT 5' *template strand*

5' _____ *3' new strand*

What is the sequence of the new strand?

6 The 3' end of a DNA strand has a phosphate at the end.

- True
- False

7 Why does a DNA strand only "grow" in the 5' to 3' direction?

A because DNA can only add nucleotides to the 3' end of the molecule

B because DNA can only add nucleotides to the 5' end of the molecule

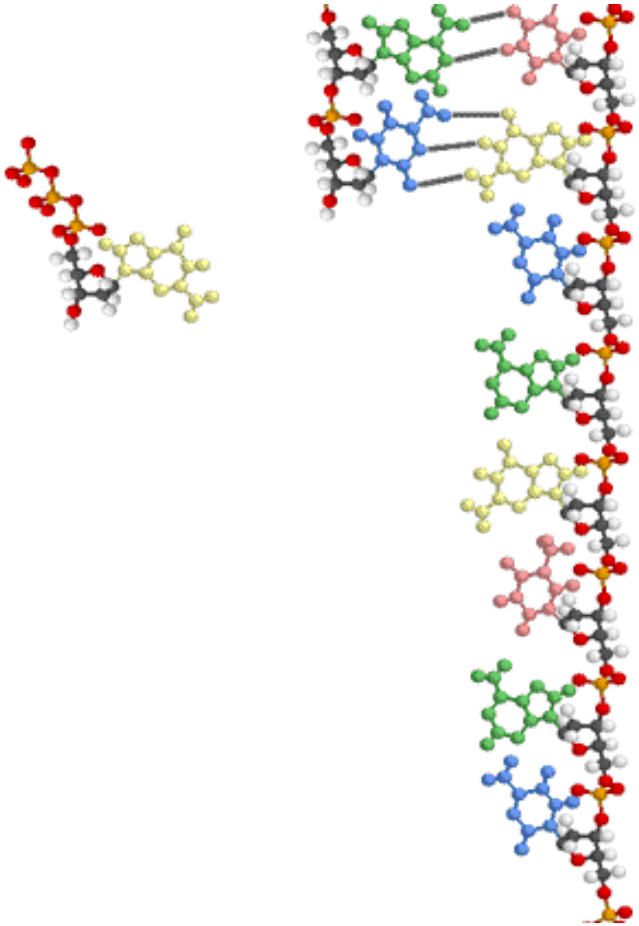
C because mRNA can only read a DNA molecule from 5' to 3'

D because mRNA can only read a DNA molecule from 3' to 5'

8 If the parent DNA strand is 5' ATCGATACTAC 3',what will the daughter stand be?

- A 5' TAGCTATGATG 3'
- B 3' ATCGATACTAC 5'
- C 5' UAGCUAUGAUG 3'
- D 3' TAGCTATGATG 5'

Enzyme Catalyzed Reaction



DNA nucleotide monomers are made ahead of time and stored in the cell.

DNA polymerase is the enzyme responsible for adding each new nucleotide to the growing strand.

Biotech Application

Polymerase Chain Reaction (PCR) is a technique which uses the principles of DNA replication to amplify the amount of DNA available for testing and manipulation.

This reaction is carried out by a special machine that utilizes repeating cycles of heat, DNA polymerase, DNA primers and free nucleotides to build copies of the DNA fragment.

This technology enables small amounts of DNA to be turned into large amounts.

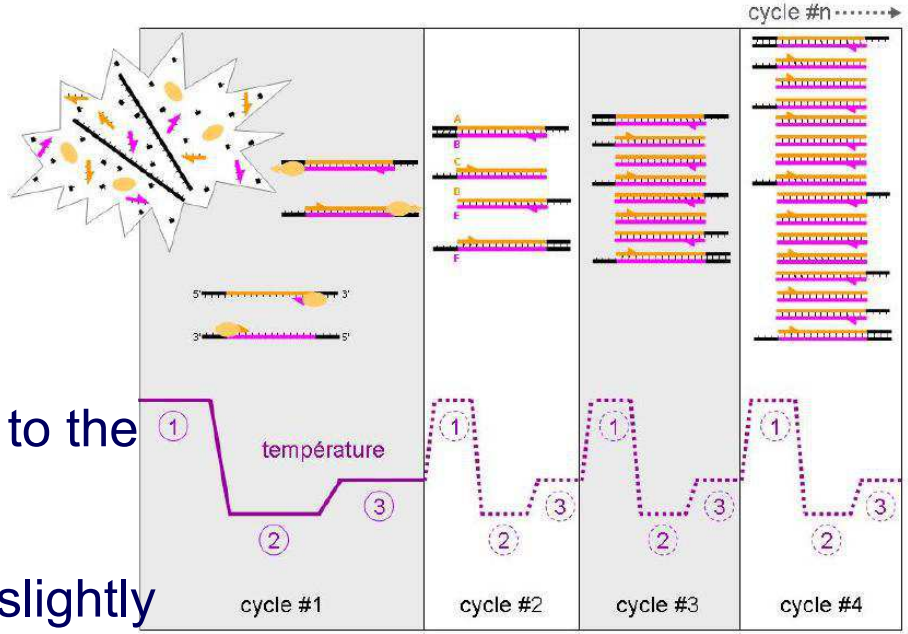
Click here to see an animation of the mechanism of PCR

Polymerase Chain Reaction

1. DNA is heated to high temperature, the DNA strands denature,separating the double helix

2. DNA is cooled, primers and polymerase in the mixture stick to the DNA

3. The temperature is increased slightly to increase the rate of replication



The cycle is repeated, doubling the amount of DNA each cycle.

9 A single DNA molecule is placed in a PCR machine. After 5 cycles, how many copies of DNA will be present?

10 A single DNA molecule is placed in a PCR machine. After 10 cycles, how many copies of DNA will be present?

11 *Taq* polymerase is typically used in polymerase chain reactions. This polymerase enzyme is found in thermophilic bacteria, *Thermus aquaticus*. What is the best explanation for the use of this enzyme?

- A Enzymes from thermophilic bacteria are stable at high temperatures
- B Most polymerases do not work in different organisms - scientists discovered that *Taq* polymerase is universal.
- C Ethical objections exist to the use of human macromolecules, such as DNA polymerase
- D Polymerases from thermophilic bacteria are not denatured at high pH.

Transcription

Return to
Table of
Contents

RNA

RNA is essential for bringing the genetic information stored in the DNA to where it can be used in the cell.

Recall that RNA is made up of a sugar molecule and phosphate group "backbone" and a sequence of nitrogen bases:

These bases hydrogen bond in pairs: A bonds to U and G bonds to C.

RNA

A strand with bases in the sequence:

ACUAGGUACAUG

has a different shape, and functions differently, than a strand with the sequence:

CUAGAACAGUCAA

Letter changes result in a new shape, and new functions.

12 RNA is more stable than DNA.

- True
- False

Transcription

Transcription is the process by which RNA strands are synthesized from DNA strands.

This is the first step in the transport of the genetic information contained in DNA.

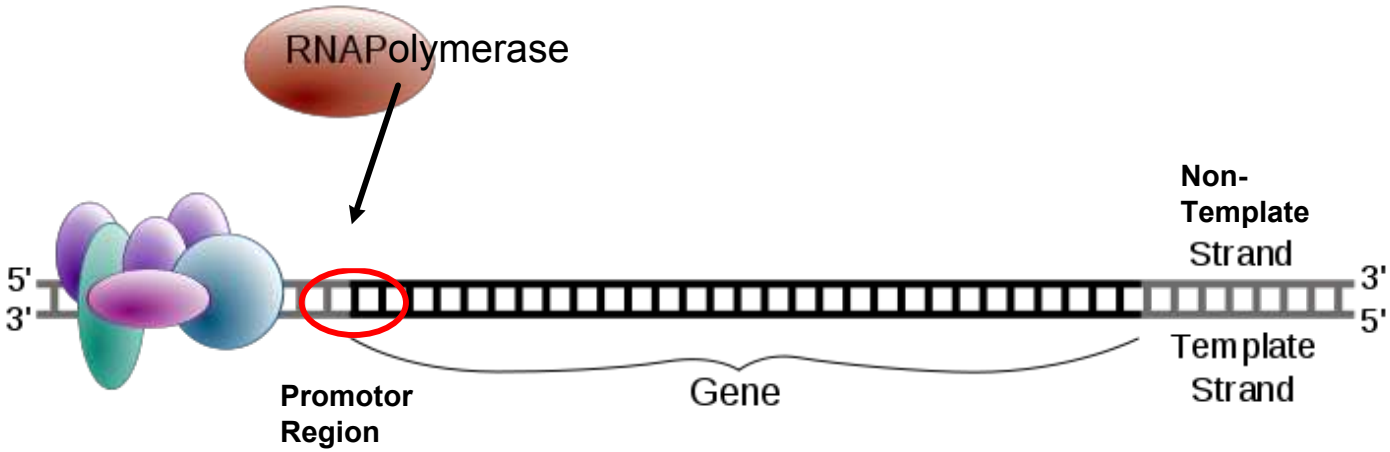
Transcribe means to write out or rewrite, you can remember that the process of making RNA from DNA is called transcription because the DNA sequence of nucleotides is being rewritten into the RNA sequence of nucleotides, which differ only slightly.

The process of transcription is very similar to that of DNA replication.

Transcription - Initiation

To begin, an enzyme called RNA Polymerase attaches to the Promoter region on the DNA.

The Promoter is a specific sequence of bases that the RNA polymerase recognizes.



Template vs. Non-Template Strands

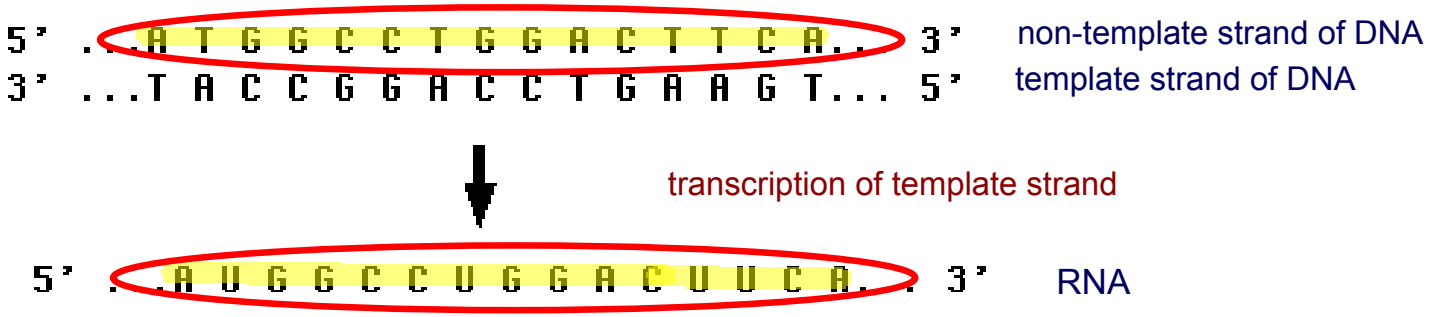
The RNA polymerase never attaches to the strand that actually contains the gene.

The strand with the genes is called the "non-template strand."
This **IS NOT** the strand that is transcribed.

The other strand is the mirror image of the first, it carries the mirror image of the gene, not the gene itself. It is called the "template strand."
This **IS** the strand where the RNA polymerase attaches.

Transcription: DNA Strands

This makes sense in that the RNA will be the mirror image of the DNA it is transcribed from. And the non-coding strand is the mirror image of the gene.



Note:
the non-template strand of DNA (the gene) matches the new RNA strand

13 The strand that is transcribed into RNA is called the _____ strand.

- A Template
- B Non Template
- C RNA
- D Amino Acid

14 The transfer of genetic material from DNA to RNA is called:

- A translation
- B transcription
- C elongation
- D promotion

15 Genes are located on the _____ strand.

- A Template
- B Non Template
- C RNA
- D Amino Acid

16 What is the function of the promoter sequence on the DNA?

- A it is where the RNA polymerase recognizes and binds to initiate transcription
- B it is where the RNA gets copied
- C it where transcription terminates
- D it is where the RNA polymerase binds to on the 3' end of the DNA initiating transcription

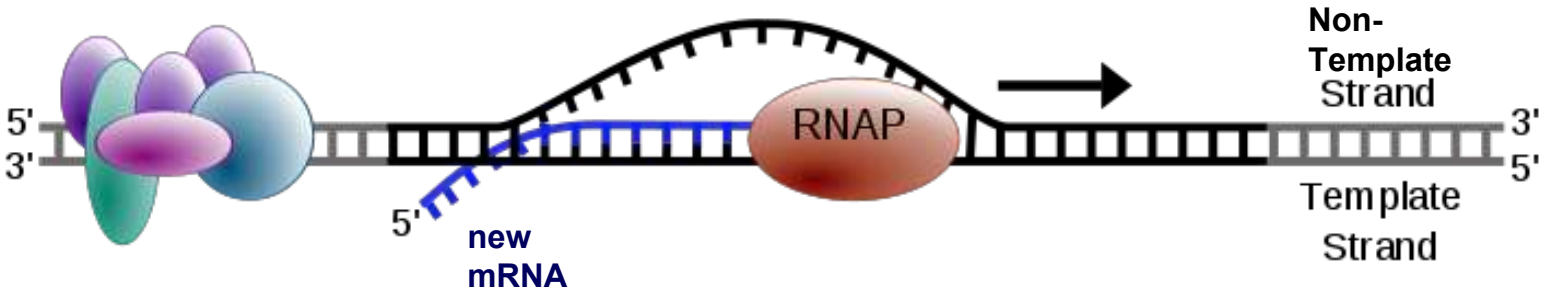
17 The strand that is NOT transcribed into RNA is called the _____ strand.

- A Template
- B Non Template
- C RNA
- D Amino Acid

Transcription - Elongation

To make the RNA strand,RNA Polymerase runs down the DNA template strand reading the bases and bringing in the new RNA nucleotides with the proper complementary bases.

As the RNA Polymerase runs down the DNA, it actually unwinds the DNA!



Base Pairing

Transcription is made possible by the fact that the different bases are attracted to one another in pairs.

Note: In DNA replication adenine paired with thymine, in DNA transcription uracil is now paired with adenine. Remember that RNA does not contain thymine as a nucleotide base.

Transcription

Just like in DNA replication, RNA is made from the 5' end to the 3' end.

DNA
("template strand")

3' TACGGCATTA 5'

RNA

5' AUGCCGUAAU 3'

(being made in 5'--------->3' direction)

18 If the template strand of DNA is 5' ATAGATACCATG 3', which is the RNA strand produced from transcription?

- A 5' UAUCUAUGGUAC 3'
- B 5' TATCTATGGTAC 3'
- C 3' UAUCUAUGGUAC 5'
- D 3' TATCTATGGTAC 5'

19 If the template strand of DNA is 5' AAAGACACTATT 3', which is the RNA strand produced from transcription?

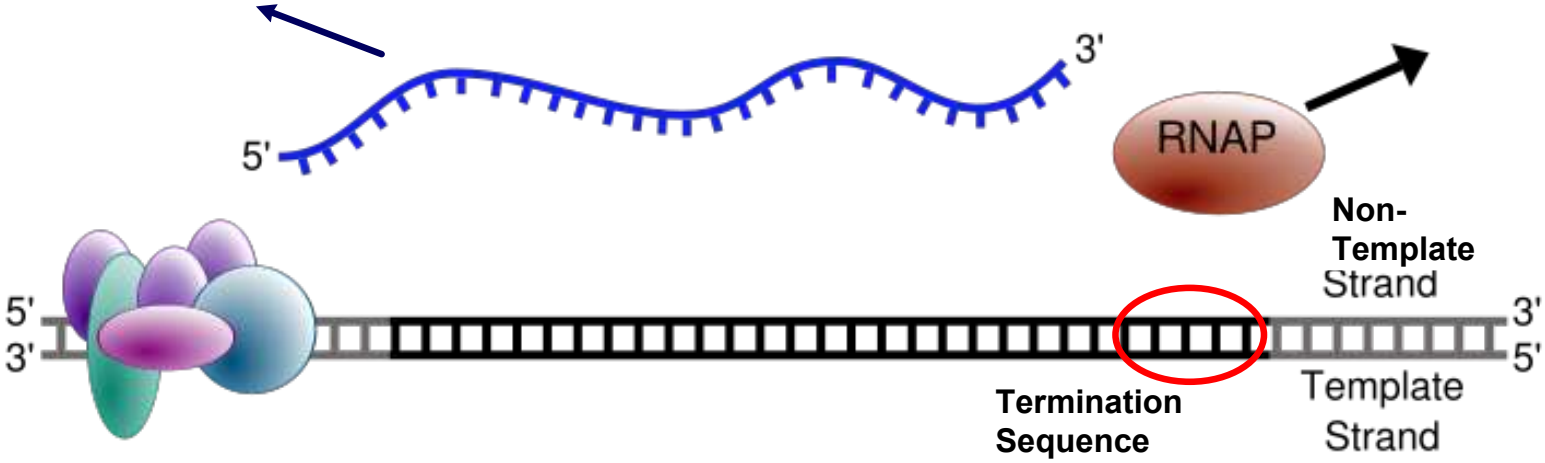
- A 5' UUUCUGUGAUAA 3'
- B 5' TTTCTGTGATAA 3'
- C 3' UUUCUGUGAUAA 5'
- D 3' TTTCTGTGATAA 5'

20 If the non-template strand of DNA is 3'ACGATTACT5', which is the RNA strand produced through transcription?

- A 3' TGCTAATGA 5'
- B 3' UGCUAAUGA 5'
- C 5' UGCUAAUGA 3'
- D 3' ACGAUUACU 5'

Transcription - Termination

RNA Polymerase gets to a sequence on the DNA called a Termination Sequence. This sequence signals the RNA Polymerase to STOP transcription.



The RNA Polymerase falls off the DNA.
The new RNA strand separates from the DNA.
The DNA recoils into a helix.

Click here to see an animation of transcription

DNA Replication vs. Transcription

DNA Replication	Transcription
Two new _____ stranded DNA are produced	One new _____ stranded RNA is produced
Adenine from the parent strand bonds with _____ on the new daughter strand of DNA	Adenine on the DNA strand bonds with _____ on the new RNA strand.
The whole _____ molecule is replicated	Only the strand with the code for the _____ is transcribed.

Synthesis of both occur in the _____' to _____' direction

Gene Expression Overview

Return to Table of Contents

Evolution

Remember that eventually, the functions performed directly by RNA were taken over by _____.

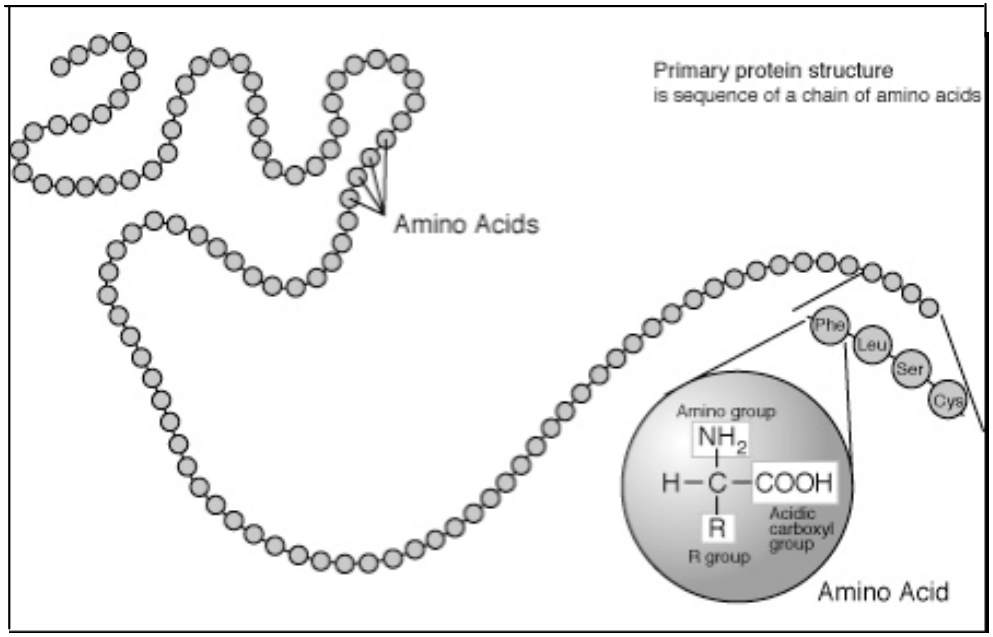
The shapes of proteins are determined by the sequence of their _____. Proteins must be "coded" with the correct sequence of amino acids to have the right shape.

There has to be a way to translate from the sequences of bases in RNA to a sequence of amino acids in a protein.

Gene Expression

Gene expression is the process of taking the "code" in the nucleic acid and making the product it codes for - the protein.

Gene expression occurs whenever a specific protein is needed by the cell.



DNA to RNA to Protein

Expressing the information stored on a gene into a protein requires two things to happen.

First, the information must be translated from the 4 letter language of DNA to RNA.

Then from the 4 letter language of RNA, it must be translated to the 20 letter language of proteins (their amino acid sequence).

Codons

The mRNA "message" is read in 3-letter words called codons. Each codon codes for an amino acid or tells the process to stop.

There are 64 codons (4x4x4) but only 20 amino acids. So some codons code for the same amino acid.

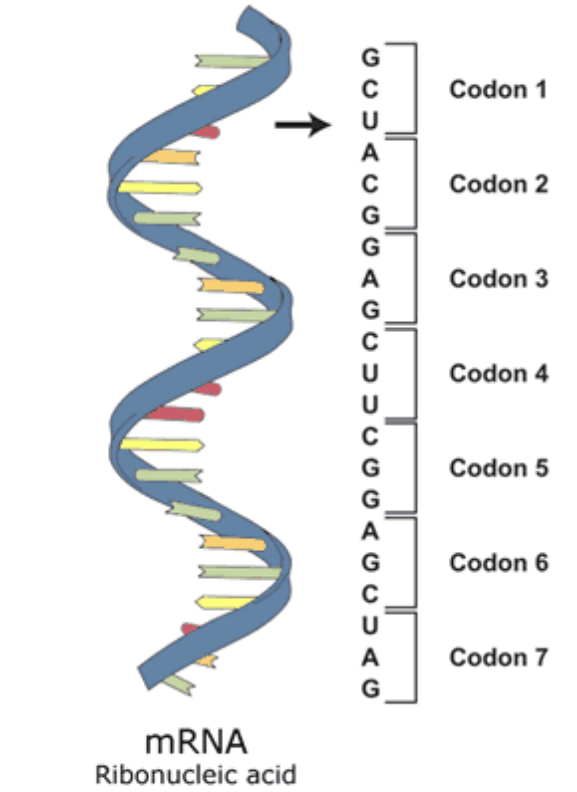


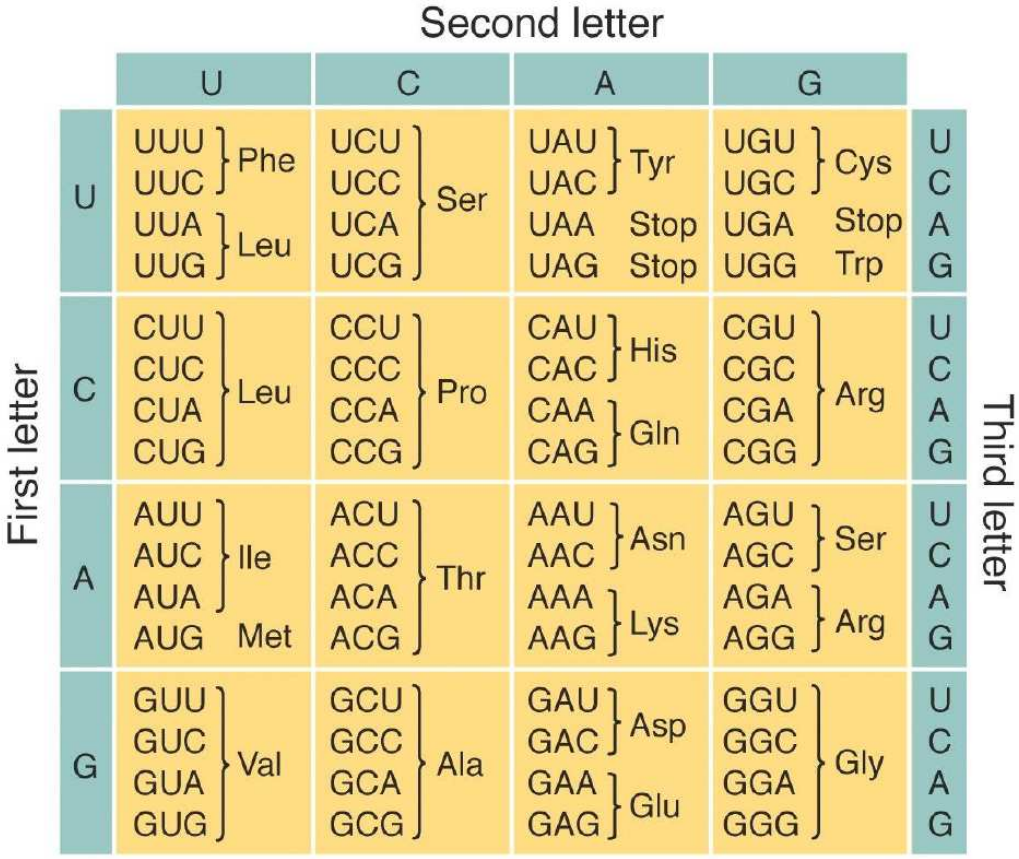
Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion/DIR//VIP/Glossary/Illustration/codon.shtml.

The Universal Genetic Code

· 61 of the codons code for an amino acid

· 3 of the remaining codons are "STOP" codons that do not code for an amino acid. They just signal that translation is over.

· 1 codon that codes for the amino acid "methionine" is also the "START" codon. Methionine is always the first amino acid in a protein.



The Universal Genetic Code

This is called a "universal" code because ALL LIFE uses the same genetic code... from the smallest bacteria or virus to the largest animal or tree.

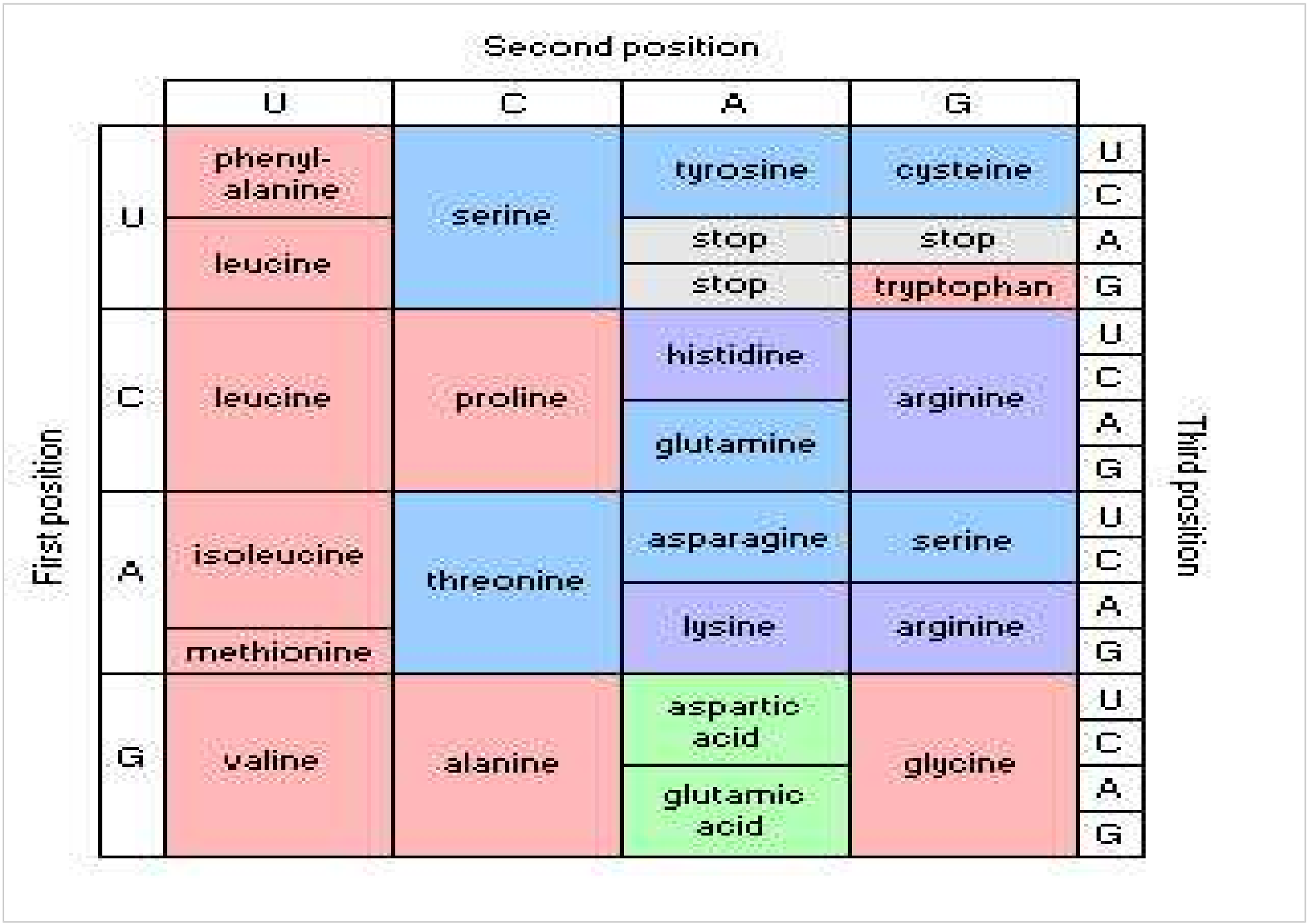
This tells us that this code goes back billions of years, in the first cell...or even before that.

If there were alternative codes that could work, they would have appeared in nature.

There are very minor alterations, but they are rare and insignificant in their effect.

21 What is a codon?

- A a 3 base sequence on tRNA
- B a 3 base sequence on mRNA
- C a 3 base sequence on DNA
- D B and C
- E A, B and C


Second position
U
C
A
G
First position
Third position
U
phenyl-alanine
leucine
serine
tyrosine
stop
stop
cysteine
stop
tryptophan
C
leucine
proline
histidine
glutamine
arginine
A
isoleucine
methionine
threonine
asparagine
lysine
serine
arginine
G
valine
alanine
aspartic acid
glutamic acid
glycine

22 The codon UAA specifies:

- A Adenine
- B Glycine (Gly)
- C STOP
- D Arginine
- E Valine

Refer to the codon table

23 The codon GGG specifies:

- A Adenine
- B Glycine
- C STOP
- D Arginine
- E Valine

Refer to the codon table

24 The codon GAC specifies:

- A Adenine
- B Glycine
- C STOP
- D Arginine
- E Aspartic Acid

Refer to the codon table

25 Why is Methionine the very first amino acid in all proteins?

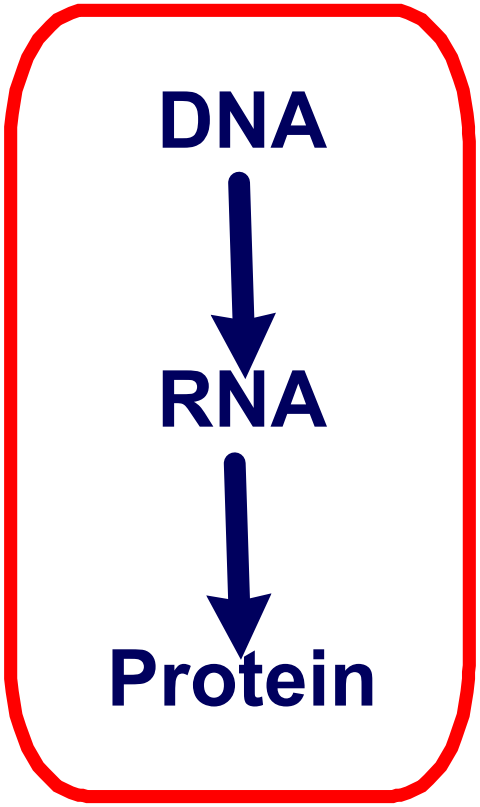
- A because it is coded by the stop codon
- B because it is coded for by AUG which is the start codon
- C Methionine is coded for by more than one codon
- D none of the above

Steps of Gene Expression

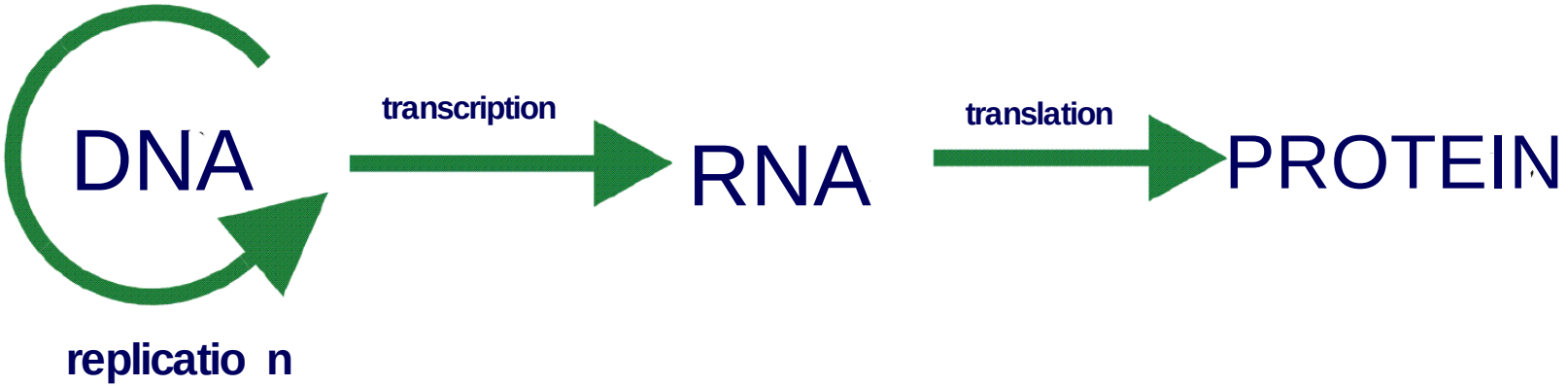
Gene expression occurs in two steps:

1. The gene is copied from DNA into RNA through a process called _____.

2. The RNA builds a protein in a process called _____.



The Central Dogma



The processes of replication, transcription and translation are so critical that they are called the Central Dogma of Biology.

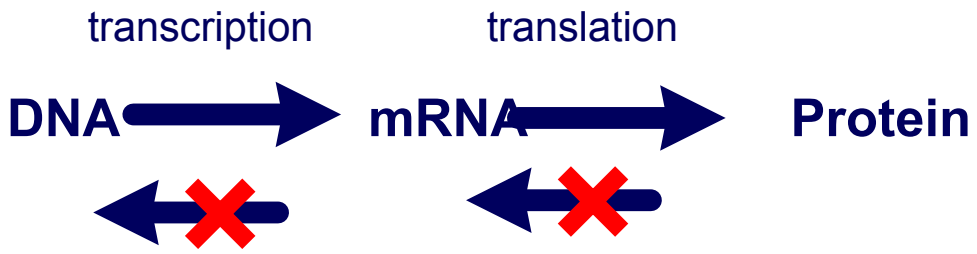
A "Dogma" is a postulate; an idea; a philosophy.

It is "Central" because it is what life is based on.

The Central Dogma

The Central Dogma is a one way process.

Changes in DNA affect mRNA and protein.



But changes in proteins or mRNA do not affect the DNA.

This will have important implications when we study genetics.

Steps of Transcription & Translation

Transcription and Translation both have 3 steps called:

Initiation - *the beginning*

Elongation - *the RNA (transcription) or protein (translation) is made longer*

Termination - *the end*

The activities that occur at each step are different for transcription and translation, but you should aware that they have the same names.

26 What is meant by "gene expression"?

- A making the protein or RNA coded in the nucleic acid
- B making amino acids so they can be made into protein
- C making tRNA only
- D folding of the protein

27 Which one of the following sequences best describes the Central Dogma of biology?

- A RNA to DNA to RNA to Protein
- B DNA to RNA to Protein
- C Protein to RNA to DNA
- D DNA to Amino Acid to RNA to Protein

Translation

Return to
Table of
Contents

Translation

Translation is the process by which RNA strands are read to build proteins.

Translate means to convert something from one language to another, you can remember that the process of making protein from RNA is called translation because the "language" of nucleotides" is being changed to the "language" of amino acids.

Three Types of RNA

Translation requires 3 types of RNA that are created using transcription.

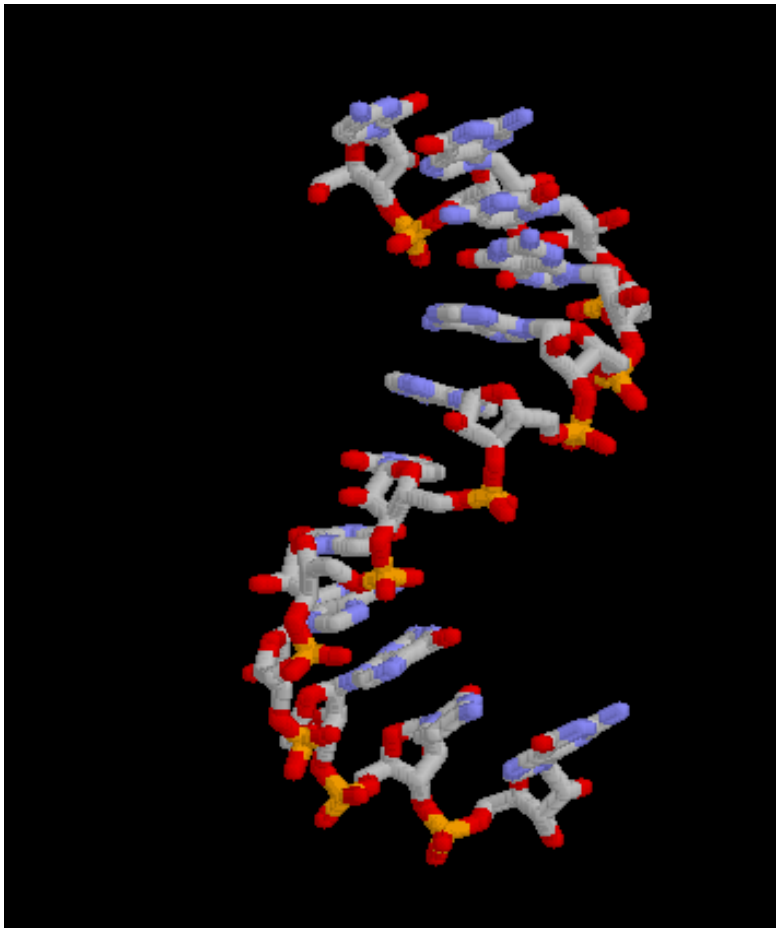
1. mRNA or messenger RNA, carries the information for protein synthesis. This type of RNA is key to The Central Dogma.

2. rRNA or ribosomal RNA, is a catalyst for protein synthesis

3. tRNA or transfer RNA, helps in the assembly of amino acids during protein synthesis

Messenger RNA (mRNA)

The specific RNA that contains the protein's information from DNA is called Messenger RNA (mRNA); it carries the genetic message to ribosomes, where it is translated.

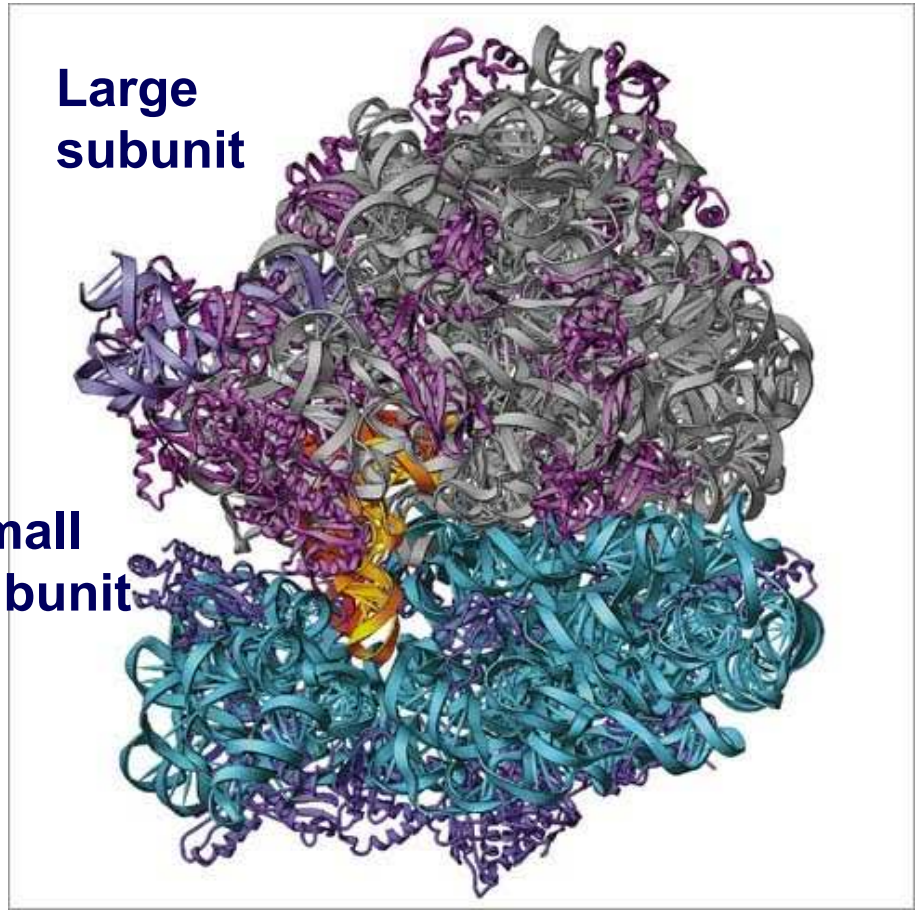


Ribosomal RNA (rRNA)

Ribosomal RNA (rRNA) and some additional proteins make up the ribosome.

The ribosome includes two subunits: one small, and one large.

During translation, the ribosome catalyzes the reaction that makes covalent bonds between amino acids, thus building the protein.



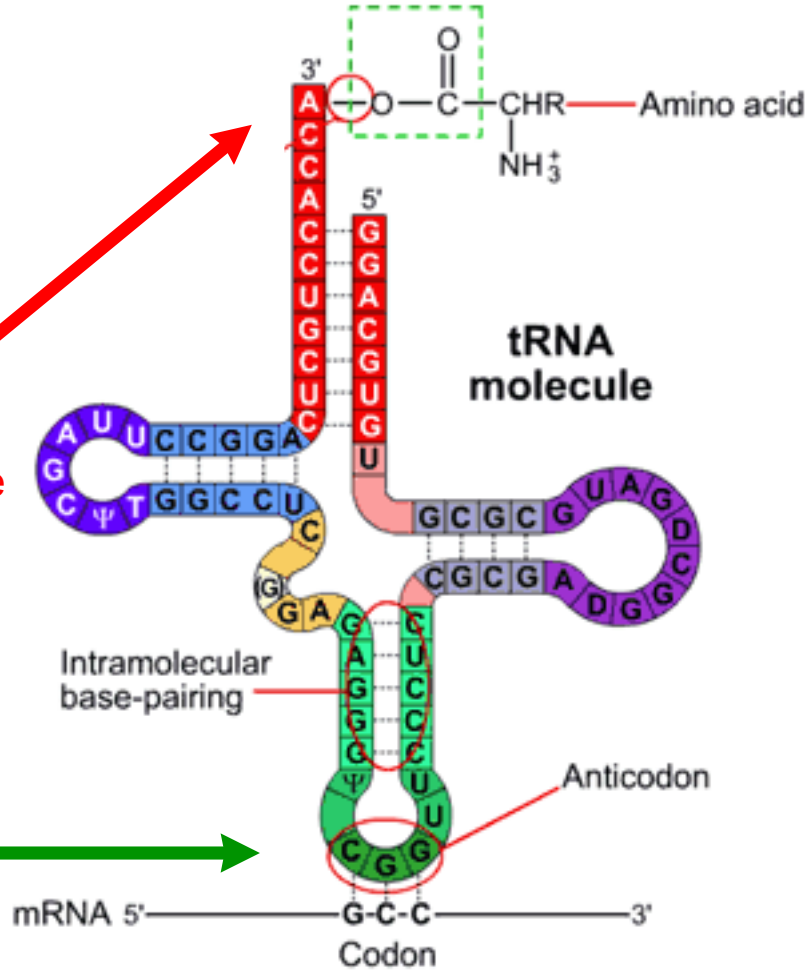
Transfer RNA (tRNA)

Transfer RNA (tRNA) carries amino acids to the ribosome so that the ribosome can covalently bond them together to form the protein.

RNA, being single stranded, can fold in on itself. In tRNA, the RNA folds into a t-shape.

The **Amino Acid Attachment Site** is where the amino acid will attach to the tRNA.

The **Anticodon** Loop is a 3 base sequence on the tip that is complementary to the codon on the mRNA.



28 What 2 components is a ribosome made of?

- A rRNA and DNA
- B rRNA and carbohydrates
- C rRNA and proteins
- D both b and c

29 What is the function of the ribosome?

- A to make an ionic bond between amino acids
- B to make a covalent/peptide bond between amino acids thus building the protein
- C to make hydrogen bonds
- D to make RNA

30 What does the "t" in tRNA stand for?

- A "transfer"- it transfers the amino acid to the ribosome and mRNA codon
- B it refers to the shape
- C "transfer"- it transfers the protein to the DNA
- D Both B and C

31 Why does tRNA fold into its specific shape?

- A The sequence and bonding of its amino acids
- B The sequence of and bonding of nucleotides
- C Its protein structure
- D A and B
- E A and C

Translation - An Overview

All the pieces are ready to begin translation:

a coded strand of mRNA
a set of 20 amino acids
ribosomes
tRNA to match all the amino acids

Translation - An Overview

tRNAs bond to the amino acid specified by their anti-codon.

The opposite side of each tRNA, the anti-codon, bonds to the matching codon on the mRNA, creating a string of amino acids in the proper sequence.

The ribosome makes covalent bonds between the amino acids.

The result is a protein chain with the specified sequence of amino acids.

Proteins: Words
Amino Acids :: Letters

The length and sequence of these amino acids allow all the proteins in the world to be created from only 20 amino acids.

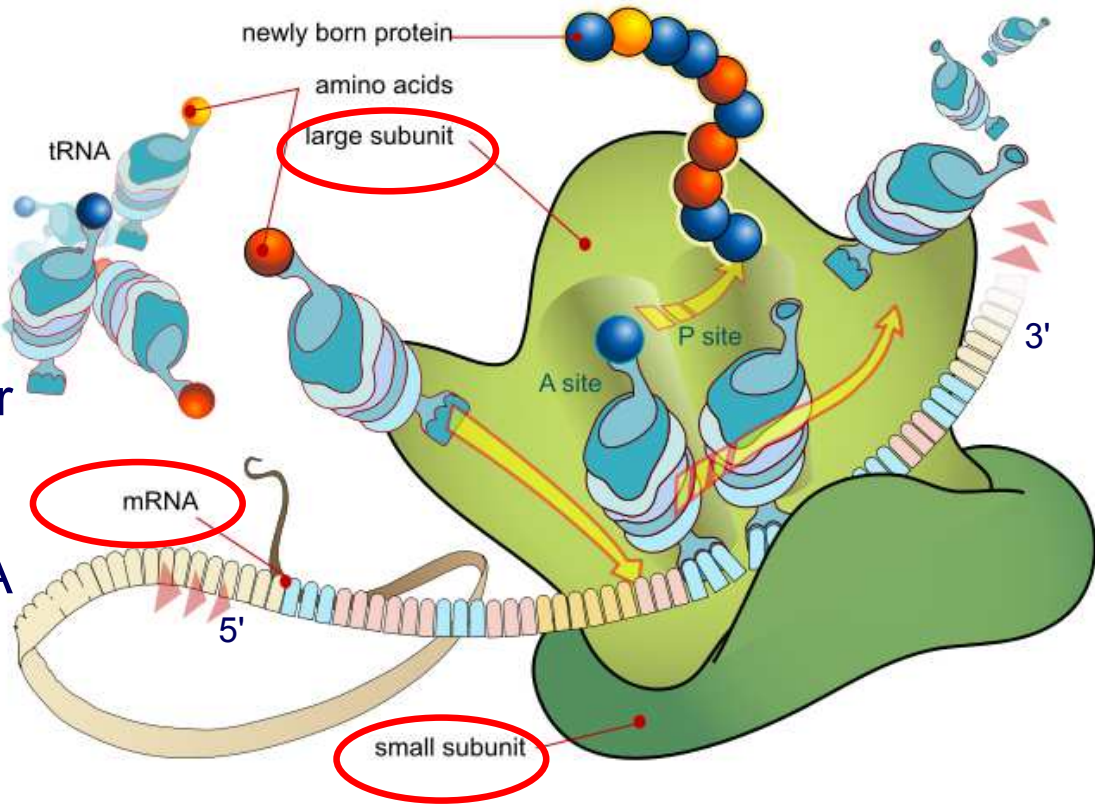
This is very similar to how all the words can be created from only 26 letters in the alphabet.

Translation - Initiation

The small subunit of the ribosome attaches to the mRNA at the bottom of the start codon(at the 5' end).

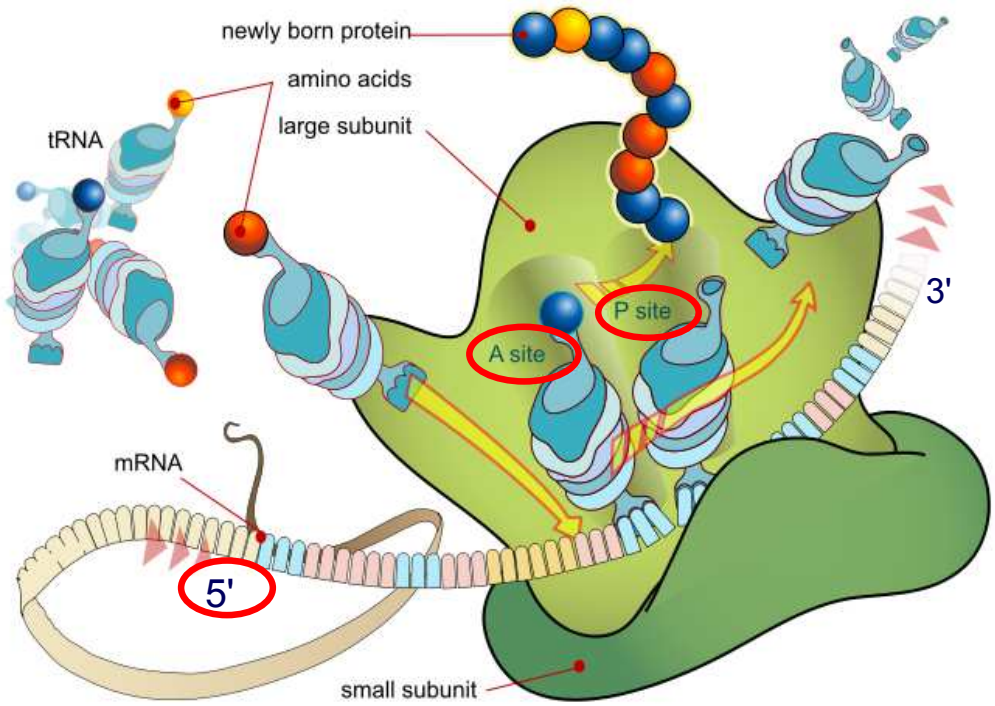
Then the large subunit of the ribosome comes in over the top.

The result is that the mRNA is "sandwiched" between the mRNA at the start codon (and the second codon as well!)



Translation - Initiation

The ribosome goes to the 5' end of the mRNA because the 5' end is the beginning of where the gene on the DNA was transcribed into mRNA.



Also notice that there are 2 sites within the ribosome.

- The P-site - where the new protein will emerge

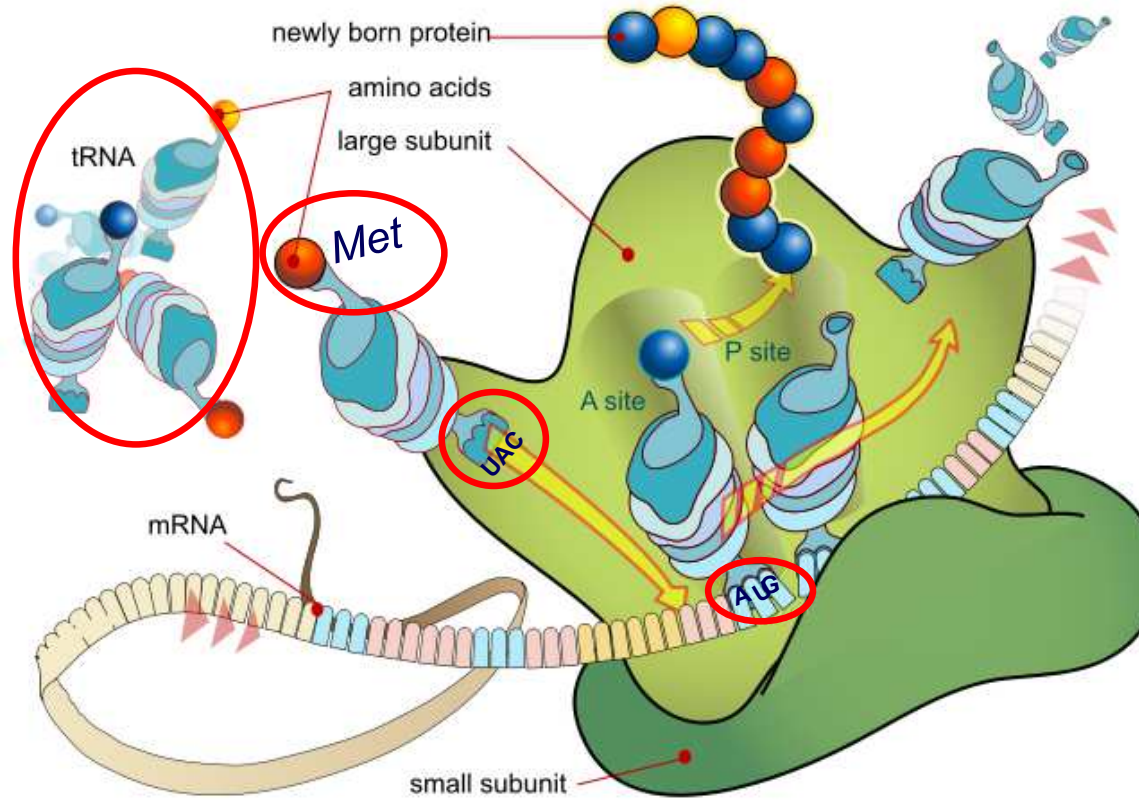
- The A-site - where the Amino Acids are delivered in

Translation - Initiation

The tRNAs, hydrogen bonded to their specific amino acids, surround the ribosome.

As the leading edge of the mRNA, with the starting code AUG, is exposed in the A site,

the tRNA with the code UAC enters the site and hydrogen bonds with it, carrying methionine into the ribosome.



Translation - Initiation

The methonine is removed from the tRNA and stays in the ribosome to be bonded with the next amino acid. The tRNA leaves the ribosome so another tRNA can enter.

Each tRNA will carry the appropriate amino acid into the ribosome to be bonded in the proper sequence, since each tRNA anticoding site matches the coding site on the mRNA, which is located at the A site of the ribosome.

Because each tRNA has an anticoding sequence it complimentary base pairs with the codon on the mRNA.

32 How does the anticodon on the tRNA and the codon on the mRNA match up?

- A by hydrogen bonding/complimentary base pairing
- B by ionic bonding
- C by peptide bonds
- D none of the above

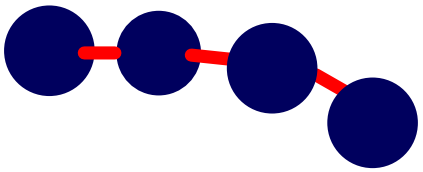
33 What is the P site of the ribosome?

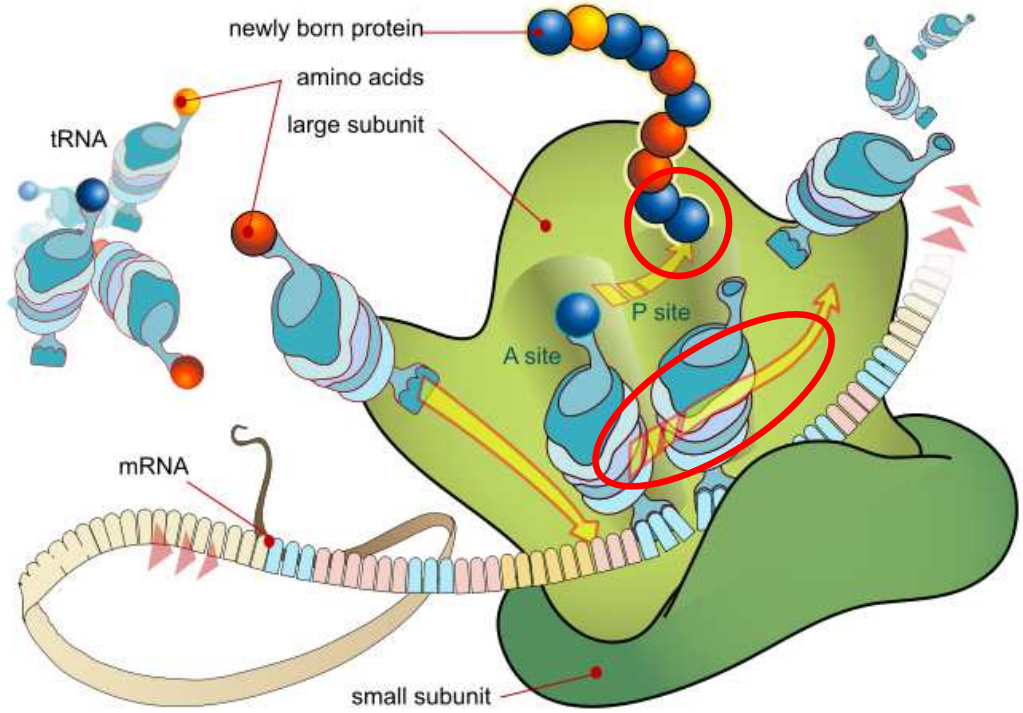
- A it is where the amino acids are delivered in
- B it is where the protein or peptide will emerge
- C it where the tRNA's will deliver in the next amino acid after each translocation
- D it is where the proteins fold into their 3-d shape

Translation - Elongation

The 2nd tRNA with its amino acid is delivered into the A-site in the ribosome.

The ribosome catalyzes a covalent bond between the amino acids.



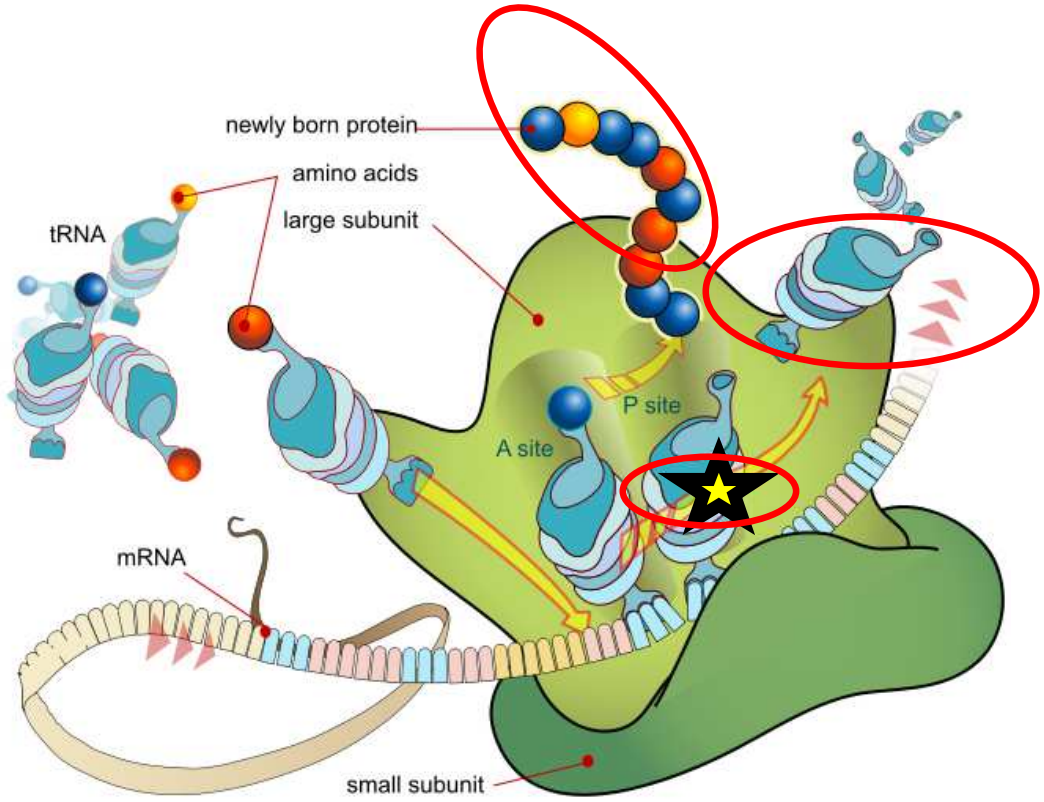


Translation - Elongation

The ribosome moves the mRNA using chemical energy.

The tRNA that was in the A-site moves to the P-site and the tRNA that was in the P-site separates from its amino acid.

Notice the protein emerging from the P-site!



Translation - Elongation

Elongation continues by adding one amino acid after another.

Each amino acid is delivered to the A-site by its matching tRNA.

The ribosome makes a peptide bond between the 2 amino acids in the P and A sites.

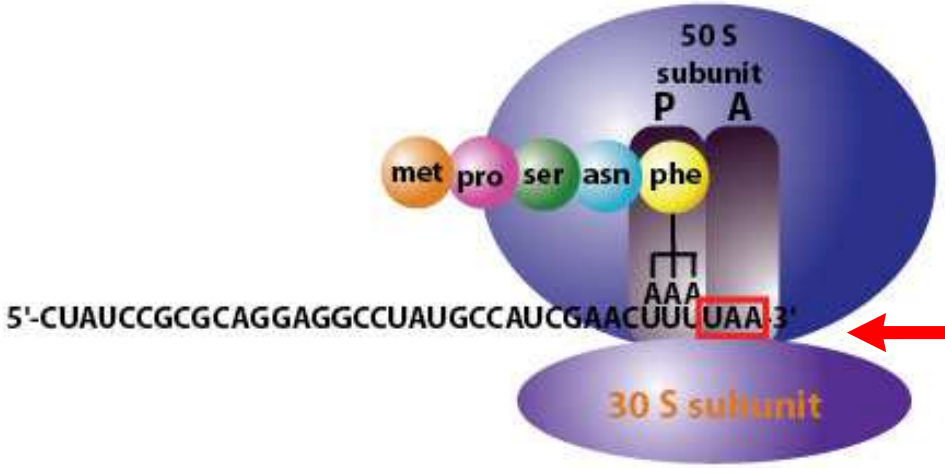
until.....

Translation - Termination

The ribosome reaches a STOP codon. Remember that STOP codons do not code for amino acids. This signals the end of translation.

The protein is complete.

The 2 subunits (large and small) separate from each other.

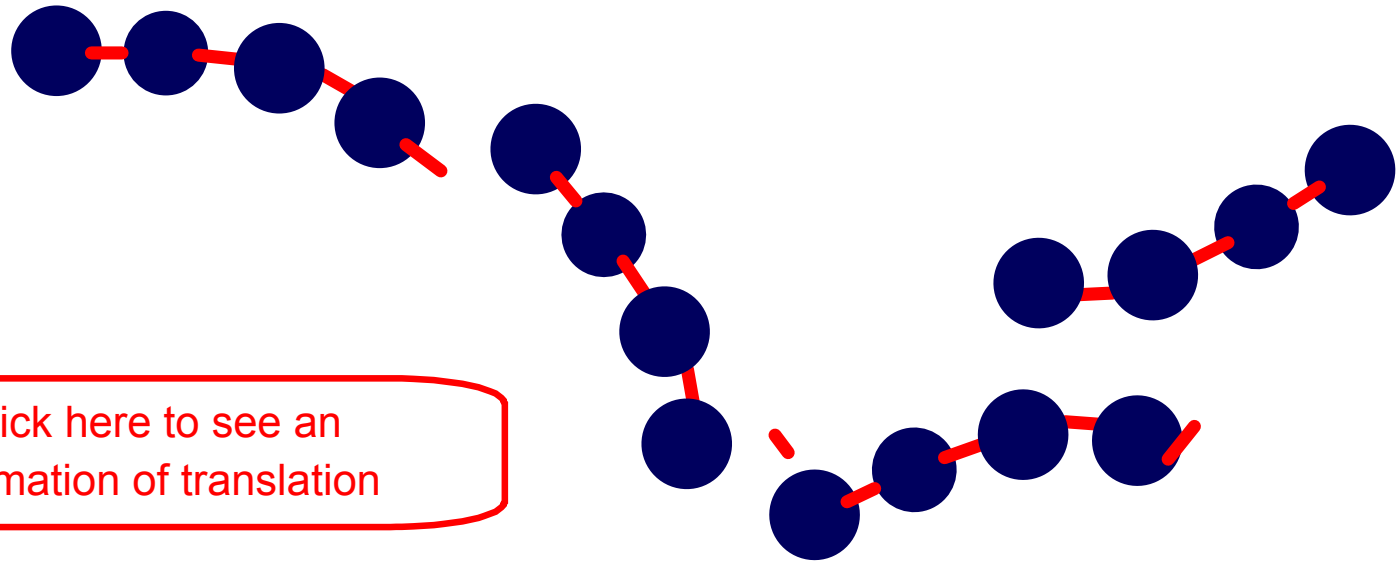


UAA is 1 of the 3 possible STOP codons.

Translation - Termination

The Result- A protein in its "primary sequence".

Remember that Primary level (1^0) of protein structure is the sequence of amino acids.



Click here to see an animation of translation

34 What is the first event of translation?

- A the tRNA comes in
- B the small subunit of the ribosome and the 1st tRNA brings in Methionine to the start codon
- C elongation happens
- D the large subunit of the ribosome comes in

35 What is the first step of translation called?

- A transcription
- B elongation
- C termination
- D initiation

36 What is the function of the ribosome in translation?

- A it makes a peptide/covalent bond between codons
- B it makes hydrogen bonds between the codons
- C it makes covalent/peptide bonds between amino acids
- D none of the above

37 What does termination in translation involve?

A translocation of the ribosome

B the ribosome gets to a stop codon and the small and large subunits of the ribosome separate

C RNA polymerase falls off the DNA

D a tRNA brings in an amino acid

38 What is translation?

- A the assembly of the amino acids from the protein code
- B assembly of amino acids coded for by the mRNA codons
- C the making of mRNA
- D assembly of codons from DNA template

39 What is a gene?

- A segment on the amino acid
- B segment on the protein
- C segment on the DNA that codes for a protein
- D segment on the RNA that codes for codons

Mutations

A mutation is a permanent change in the DNA sequence of a gene. Mutations in a gene's DNA sequence can alter the amino acid sequence of the protein encoded by the gene. Like words in a sentence, the DNA sequence of each gene determines the amino acid sequence for the protein it encodes.

The DNA sequence is interpreted in groups of three nucleotide bases, codons. Each codon specifies a single amino acid in a protein.

Substitution Mutations

When a nucleotide in a gene is copied incorrectly during DNA replication, one nucleotide can be substituted with another. This results in the incorrect amino acid sequence, changing the structure of the protein.

Correct DNASequence: AAA TTT CCC GGG AAA TTT CCC GGG

Correct RNA Transcript: UUU AAA GGG CCC UUU AAA GGG CCC

Correct Polypeptide: Phe - Lys - Gly - Pro - Phe - Lys - Gly - Pro

Substitution mutation: AAA TTT CCC GGG ATA TTT CCC GGG

Resulting Transcript: UUU AAA GGG CCC UAU AAA GGG CCC

Resulting Polypeptide: Phe - Lys - Gly - Pro -Tyr - Lys - Gly - Pro

Reading Frame Shifts

We can think about the DNA sequence of a gene as a sentence made up entirely of three-letter words.

Thesunwashot

If you were to split this sentence into individual three-letter words, you would probably read it like this:

The sun was hot

If this sentence represents a gene then each letter corresponds to a nucleotide base, and each word represents a codon. If you shifted the three-letter reading frame it would result in a sentence which is not understandable...

_ _T hes unw ash ot_

Or

Th esu nwa sho t _

Insertion and Deletion Mutations

When a nucleotide in a gene is copied incorrectly during DNA replication, a nucleotide can be added or deleted. This results in a reading frame shift and the incorrect amino acid sequence, changing the structure of the protein.

Correct DNASequence:	AAA TTT CCC GGG
RNA Transcript:	UUU AAA GGG CCC
Correct Polypeptide:	Phe - Lys - Gly - Pro
Insertion mutation:	AAA ATT TCC CGG G_ _
Resulting Transcript:	UUU UAA AGG GCC C_ _
Resulting Polypeptide:	Phe - STOP
Deletion mutation:	AAT TTC CCG GG_
Resulting Transcript:	UUA AAG GGC CC_
Resulting Polypeptide:	Leu - Lys - Gly ?

Silent Mutations

A mutation is "silent" if it has no affect on the protein coded by the gene. The redundancy in the genetic code makes this possible.

Each amino acid has more than one possible codon. So, if a substitution occurs, the same amino acid may still be coded. This reduces the possibility of a mutation located in a gene causing a change in the protein.

Ala - GCU, GCC, GCA, GCG

Leu - UUA, UUG, CUU, CUC, CUA, CUG

Arg - CGU, CGC, CGA, CGG, AGA, AGG

40 Changing one nucleotide in a DNA sequence can change _____ in a protein.

- A a polypeptide
- B the primary structure
- C the secondary structure
- D the tertiary structure
- E all of the above

41 Using AAA TTT GGG AAA as an example, which of the following would be an example of a substitution mutation?

- A TTT CCC GGG
- B AAA ATT TCC CGGG
- C ATA TTT GGG AAA
- D AAA TTT GGG AAA

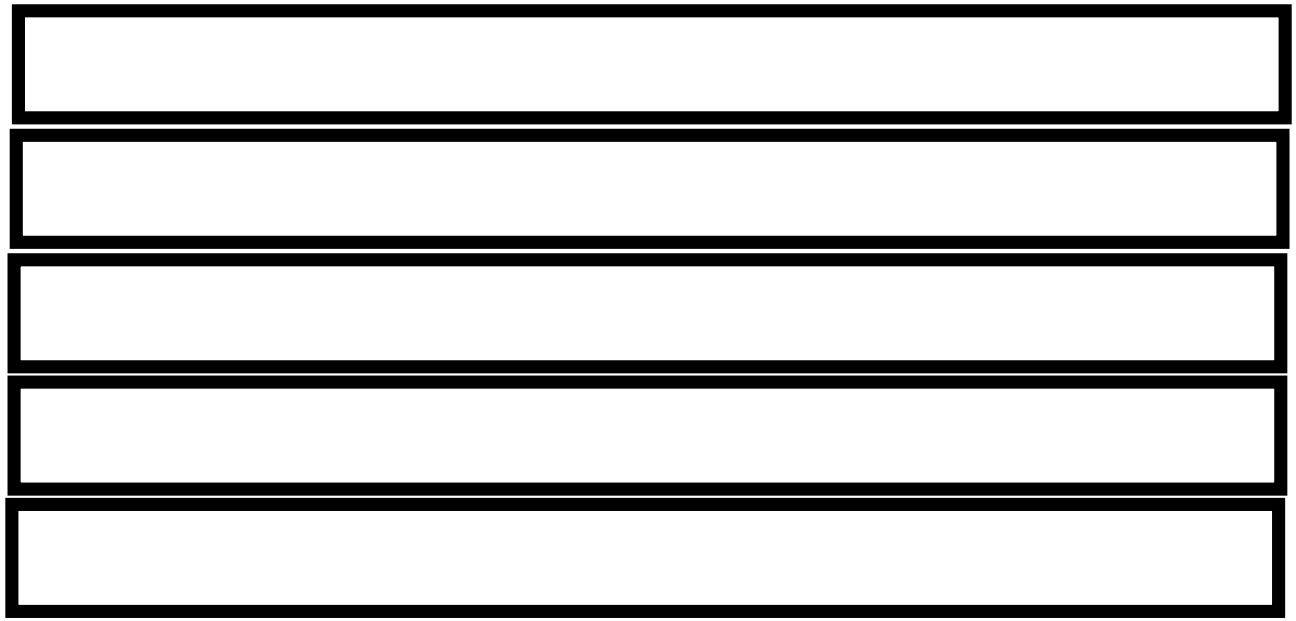
42 Using AAA TTT GGG AAA as an example, which of the following would be an example of a frame-shift mutation?

- A AAA TTT GGG AAA
- B ATA TTT GGG AAA
- C AAA ATT TCC CGG G
- D TTT CCC GGG

Mutagens

A mutagen is a physical or chemical agent that can change the DNA of an organism and thus increases the frequency of mutations.

What examples can you think of?



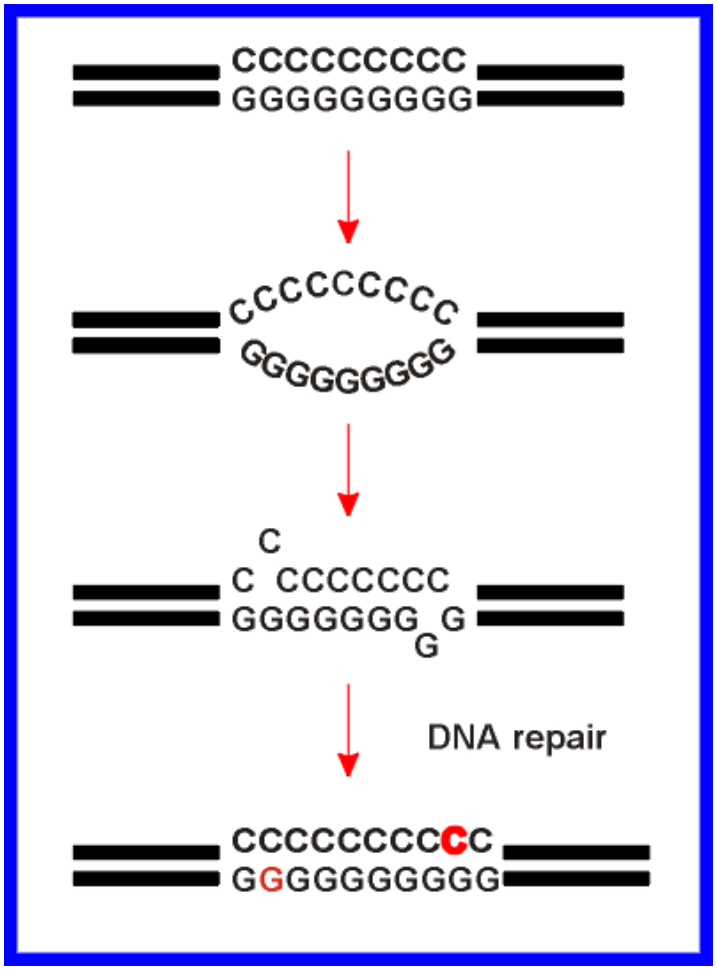
Spontaneous Mutations

Not all mutations are caused by mutagens.

Spontaneous mutations occur due to errors involving:

- Changes to the Chemistry of the DNA
- DNA replication, repair and recombination.

This shows a DNA strand slipping out of place during replication, causing a mutation in the DNA once it has been repaired.



Are mutations always bad?

Not necessarily...

Very rarely a mutation will cause an individual to become stronger than the rest of its population. Sometimes a mutation can give a prokaryote resistance to a new antibiotic or toxin.

These would be advantages to the individual and they may become better able to survive in their environment.

43 The change a mutation causes to DNA is:

- A temporary
- B always fatal
- C permanent
- D always beneficial

44 All mutations are caused by mutagens.

- True
- False