

Transcription and Translation (AHL)

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Protein Synthesis: Transcription and Translation



What is the significance of each of these terms?

sense antisense mRNA tRNA

triplet codon ribosome polysome

binding sites complementary base pairing

nucleoside triphosphates promoter regions

RNA polymerase terminator 5' - 3'

introns exons release factor

initiation elongation

translocation termination

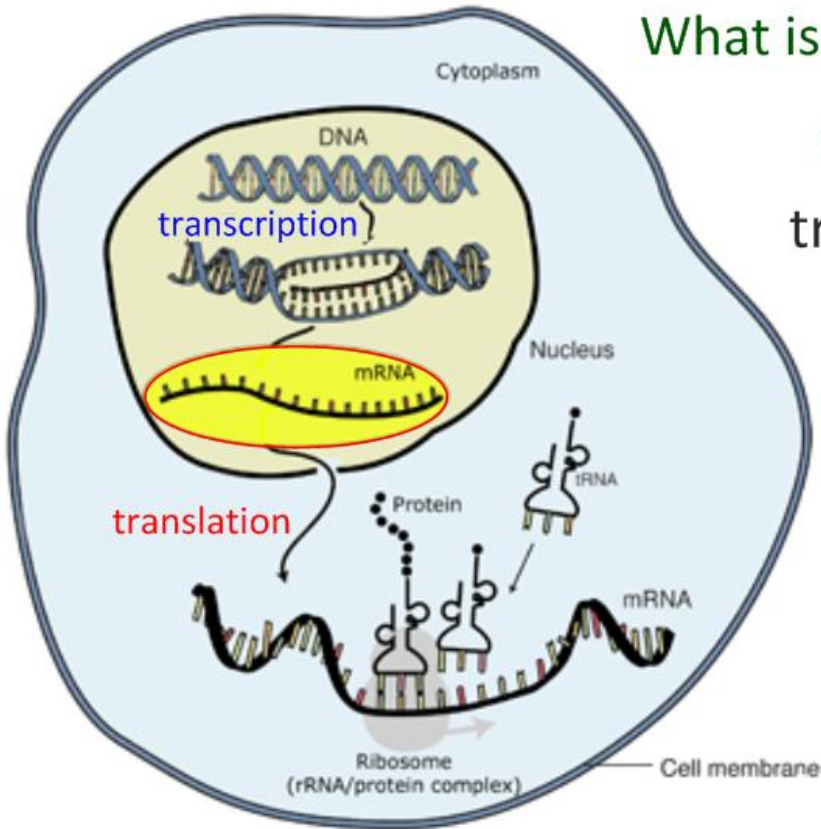


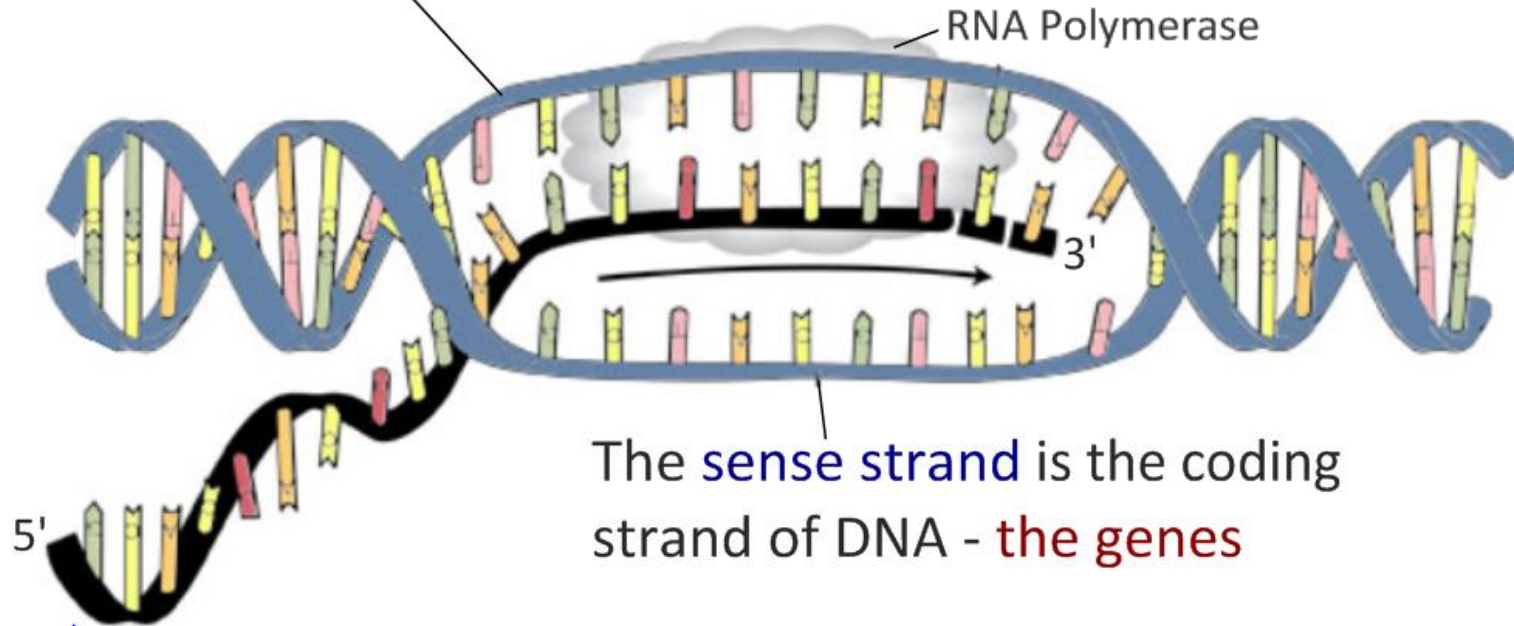
Image adapted from National Human Genome Research Institute

<http://www2.geneticsolutions.com/PageReq?id=1530:1873&InPopUp=true>

DNA has a sense strand and an antisense strand

The **antisense strand** is **complementary** to the sense strand.

It is also known as the **template strand**, as this is the strand which is used for **transcription** - making mRNA.



The **sense strand** is the coding strand of DNA - **the genes**

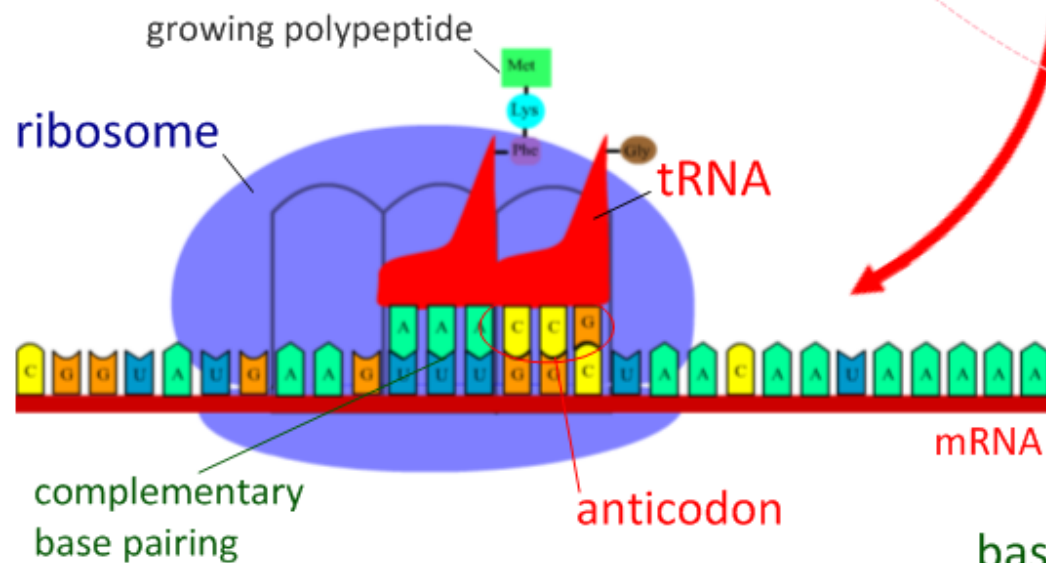
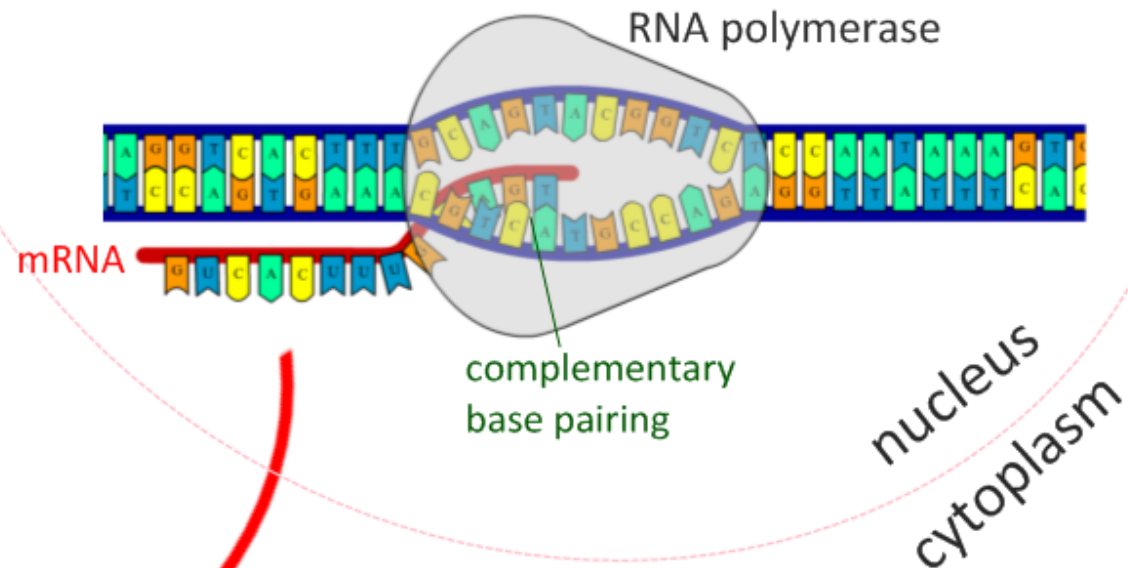
By **transcribing the antisense strand**, the **base sequence of the mRNA** will be the same as the coding DNA - except U replaces T.

Protein Synthesis: Transcription and Translation

Transcription:

RNA polymerase makes a **mRNA** molecule that is **complementary** to the **antisense strand of DNA**.

(Corresponds with sense strand- although T has been replaced with U)



Translation:

mRNA is posted out of the nucleus and attaches to **ribosomes**.

Ribosomes use **complementary base-pairing** to 'read' codons on the **mRNA**.

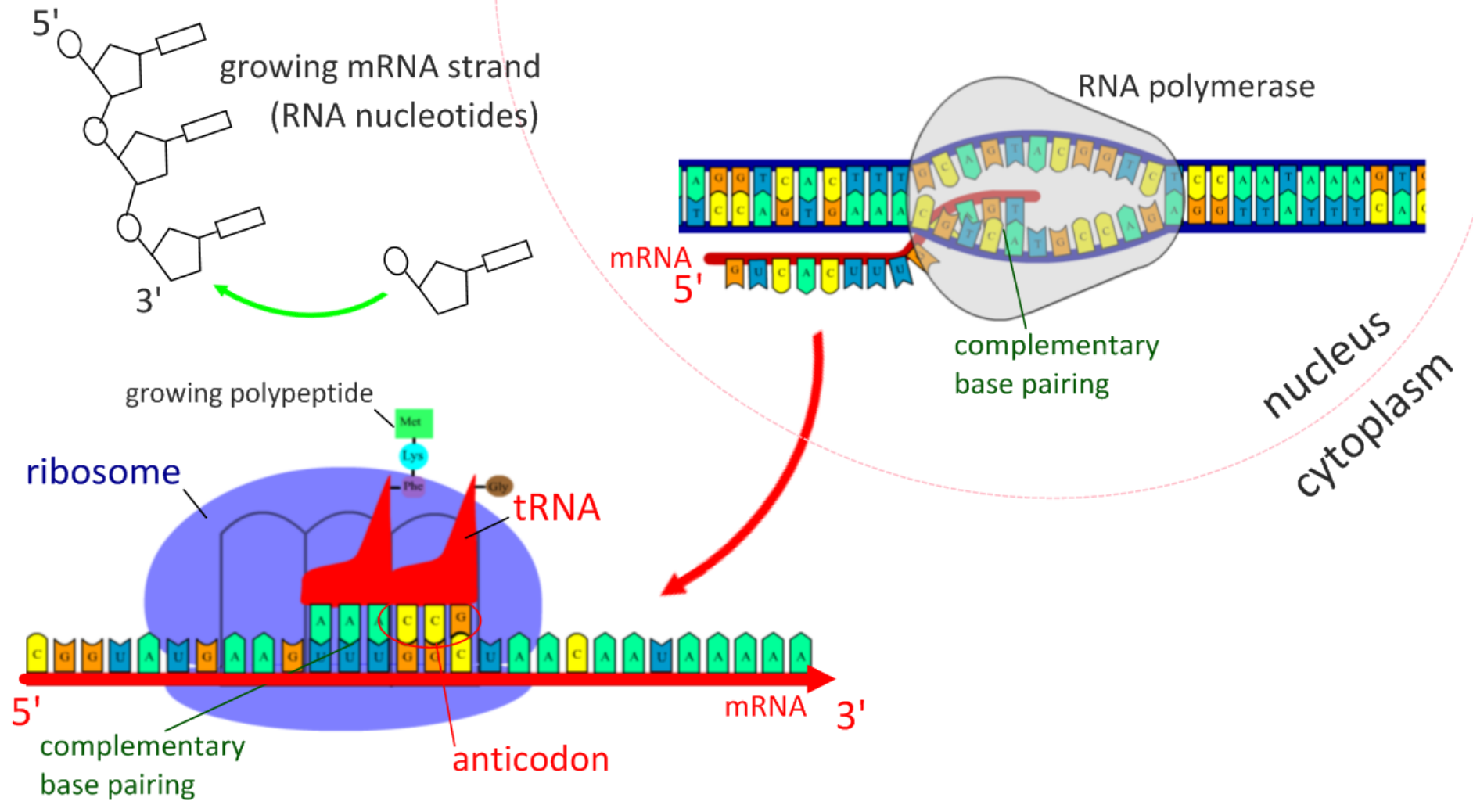
tRNA (transfer) molecules with corresponding anti-codons bring the correct amino acid.

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

Images from:

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

Transcription and Translation are both carried out in a 5'→3' direction



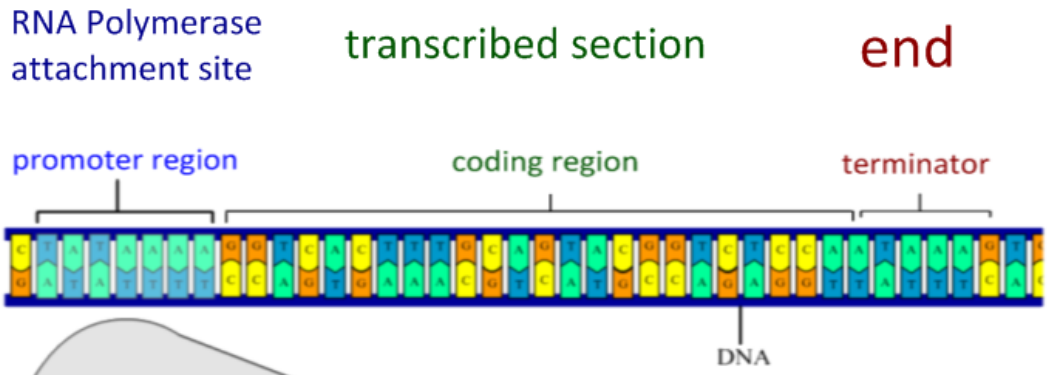
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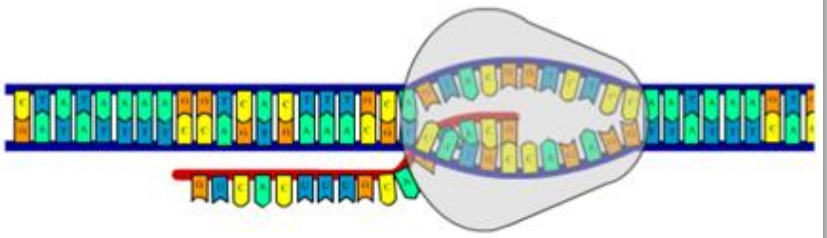
Transcription

Transcription of the gene results in an mRNA molecule which can be posted out of the nucleus. It is then translated into the polypeptide...



RNA polymerase attaches at the promoter regions and unwinds short sections of DNA.

Full animation:

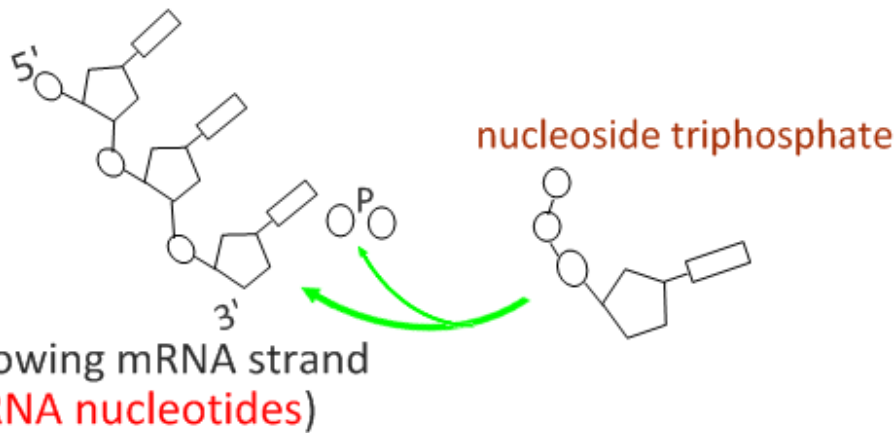


RNA polymerase moves along the antisense strand of DNA, using free nucleoside triphosphates to make a strand of mRNA.

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



mRNA is elongated until the ribosome reaches the terminator region:



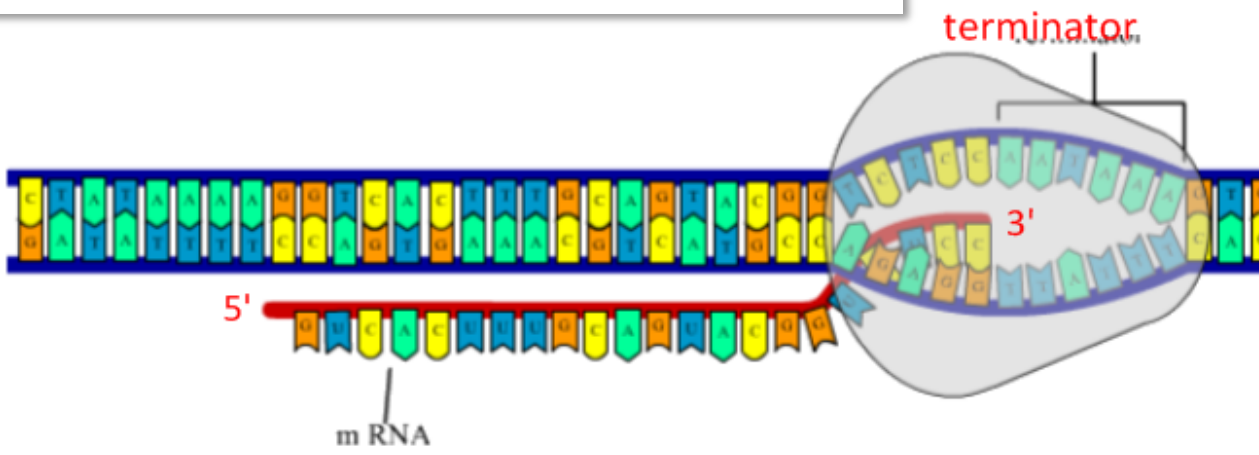
Free **nucleoside triphosphates** are found in the nucleus.

They are taken by the **RNA polymerase** and two phosphates are removed.



The resulting **RNA nucleotides** are added on to the 3' end of the growing mRNA strand.

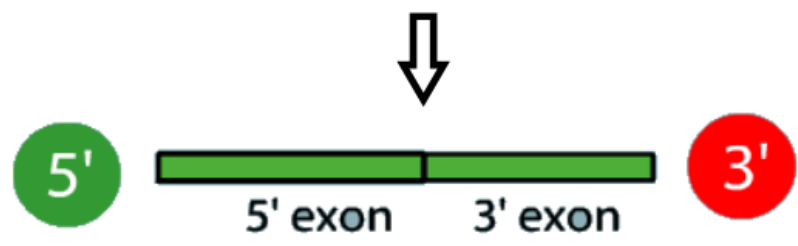
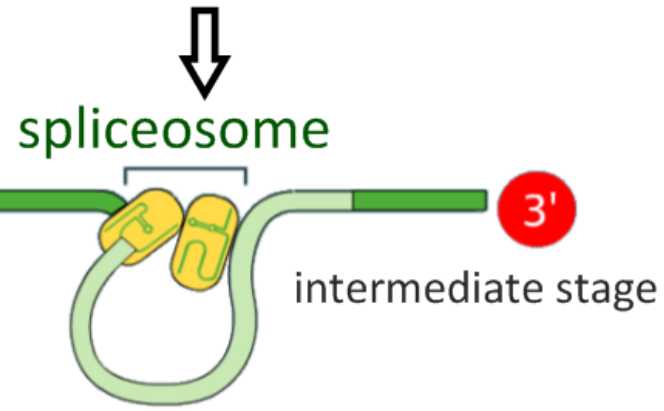
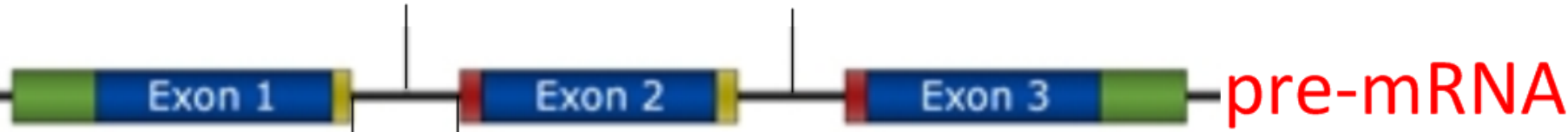
http://www.phschool.com/science/biology_place/biocoach/transcription/complete.html



RNA polymerase detaches and releases mRNA

Eukaryote pre-mRNA contains exons and introns

Introns are non-coding regions that need to be removed before translation



mature mRNA
ready for translation

Find out more:

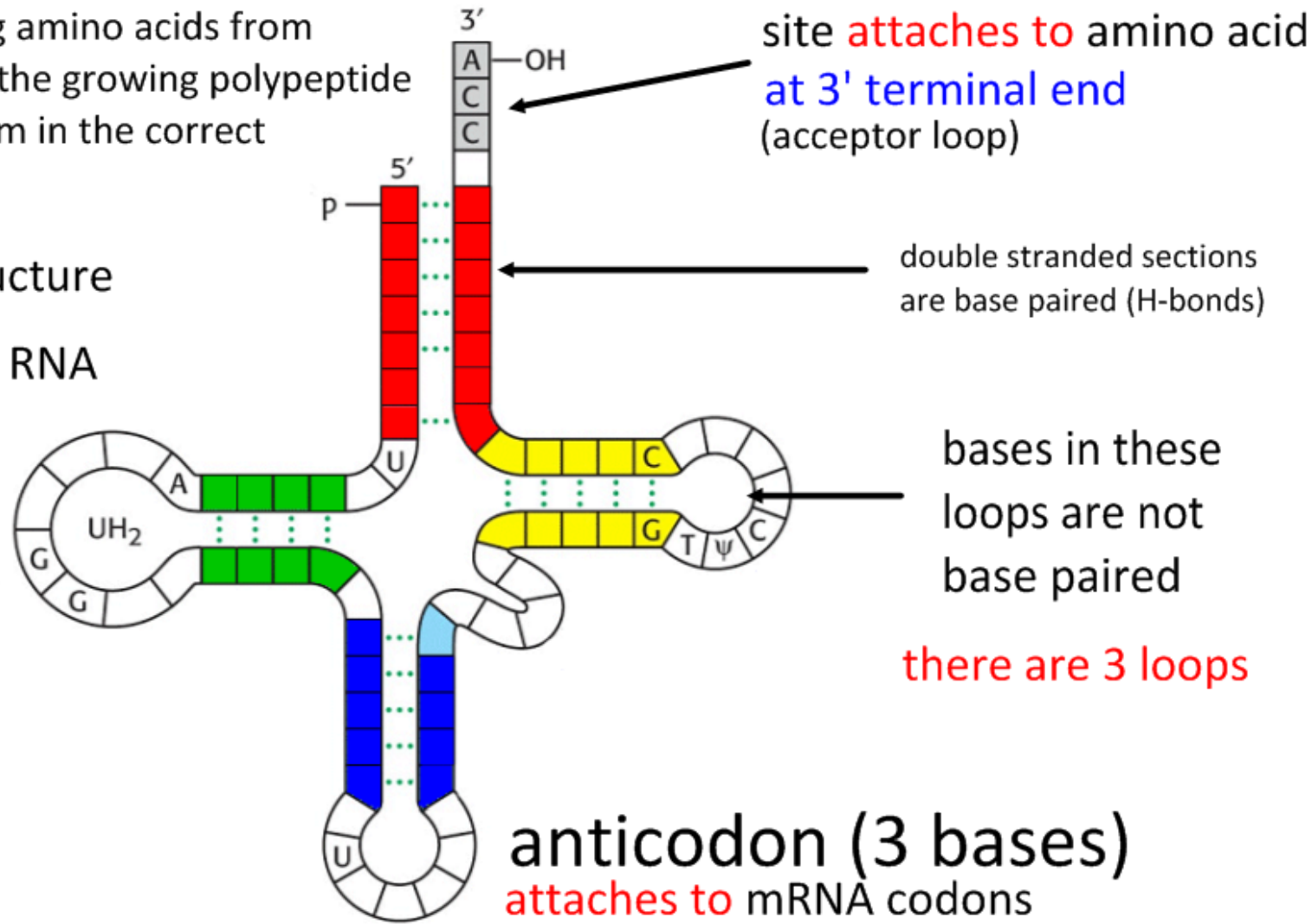
The screenshot shows an interactive animation window titled 'RNA Splicing'. At the top, there are tabs for 'Introduction', 'Animation', 'Conclusion', and 'Quiz'. The main content area shows a flowchart of the process: DNA is transcribed into DNA-RNA, which then undergoes RNA processing to become mRNA. The mRNA is then translated by a ribosome into protein. Below the flowchart, there are controls: 'INTRO', 'STOP', 'PLAY', and 'CONTINUE', along with a progress indicator '1 / 7'. A paragraph of text explains the process: 'After a eukaryotic cell transcribes a protein-coding gene, the RNA transcript, called a pre-mRNA, is processed. The processing takes place in the nucleus, after which the mature mRNA is released into the cytoplasm. Ribosomes in the cytoplasm translate the mRNA into protein.'

<http://bcs.whfreeman.com/thelifewire/content/chp14/1401s.swf>

The structure of tRNA matches its function.

Function: to bring amino acids from the cytoplasm to the growing polypeptide and to attach them in the correct location.

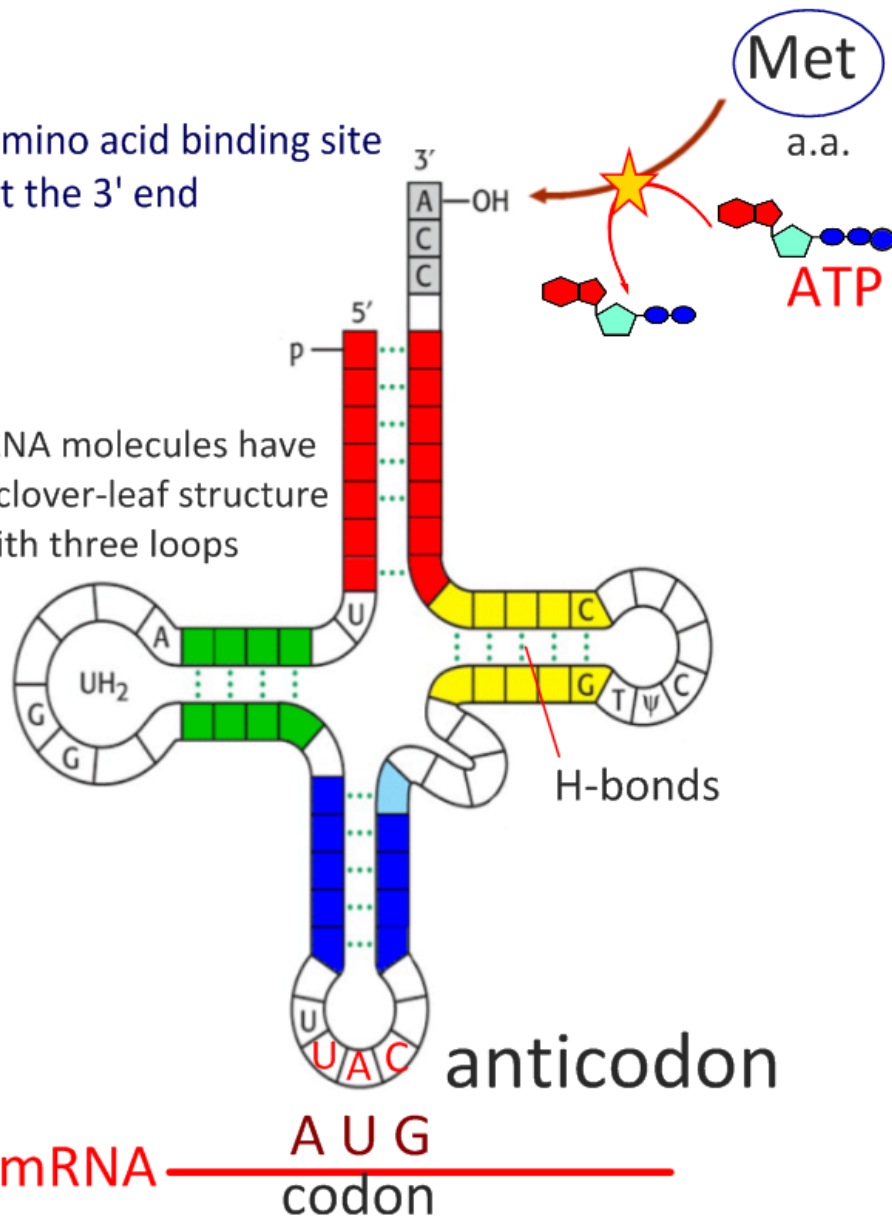
Clover-leaf structure
single chain of RNA



tRNA is activated by a tRNA activating enzyme

amino acid binding site
at the 3' end

tRNA molecules have
a clover-leaf structure
with three loops



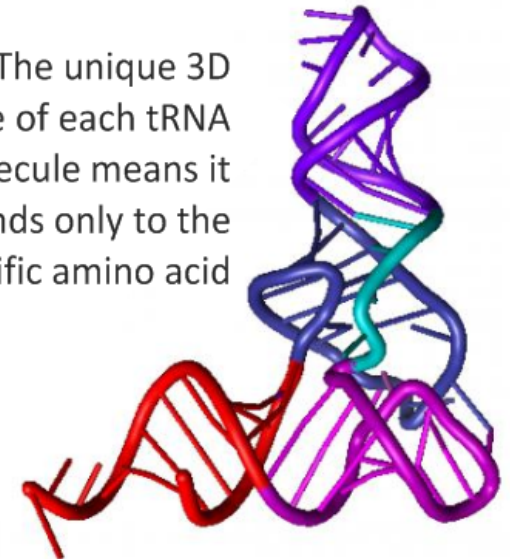
tRNA delivers amino acids to the growing
polypeptide chain in translation.

It picks up new amino acids when activated
by a specific tRNA activating enzyme.

This uses ATP.

There are **20 of these enzymes**,
corresponding to the 20 amino acids, for
which the tRNA molecule has the
complementary anticodon.

The unique 3D
structure of each tRNA
molecule means it
binds only to the
specific amino acid



tRNA is activated by a tRNA activating enzyme

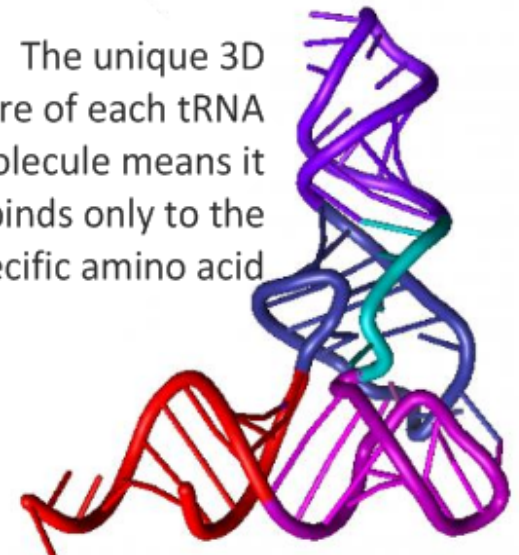
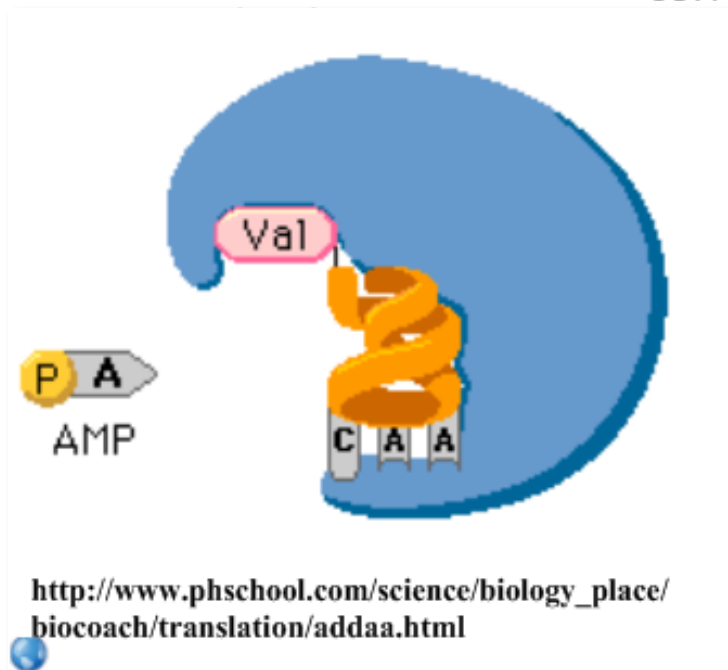
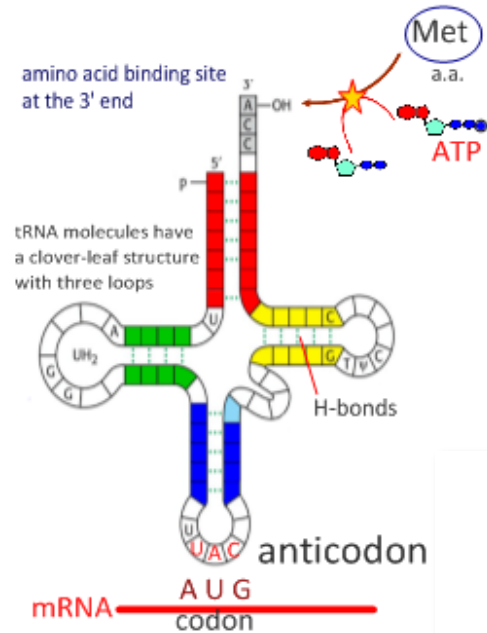
tRNA delivers amino acids to the growing polypeptide chain in translation.

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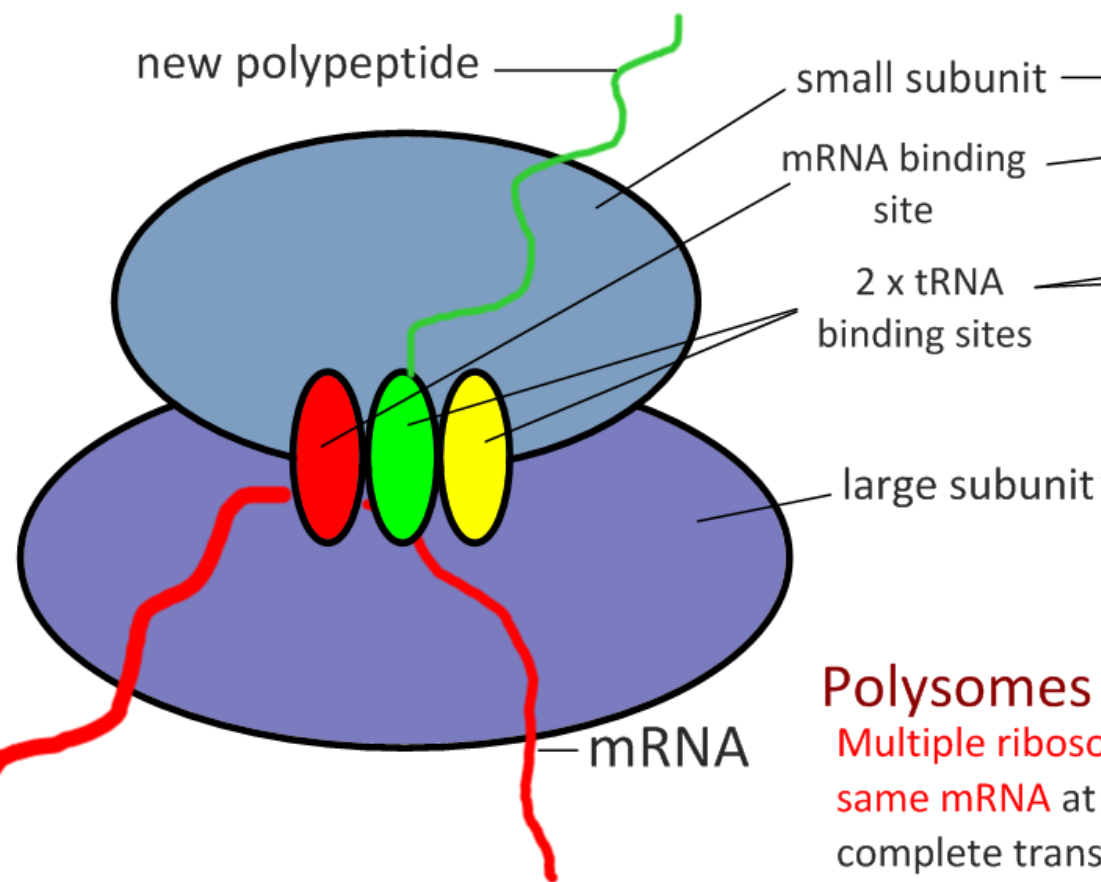
There are 20 of these enzymes, corresponding to the 20 amino acids, for which the tRNA molecule has the **complementary anticodon.**

The unique 3D structure of each tRNA molecule means it binds only to the specific amino acid

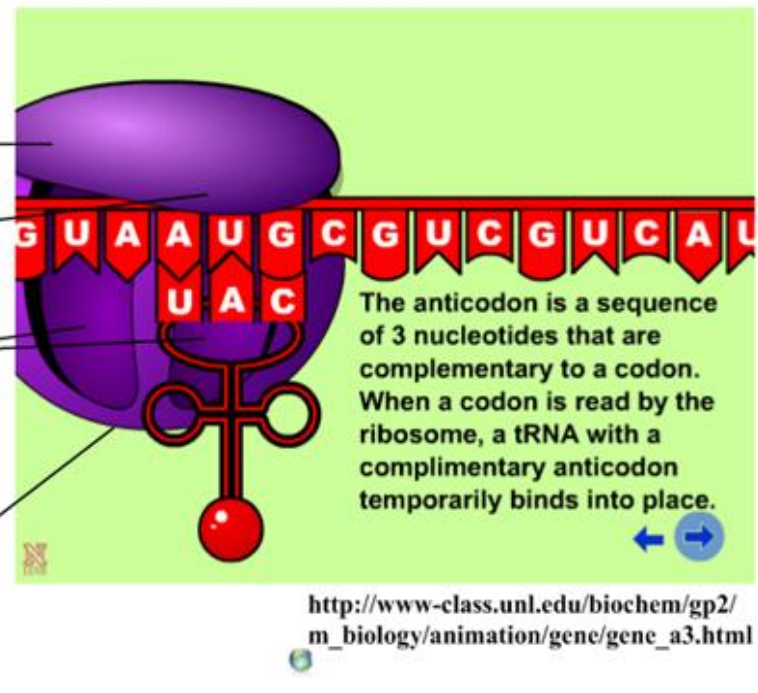


Ribosomes

Made of protein and rRNA (ribosomal RNA)



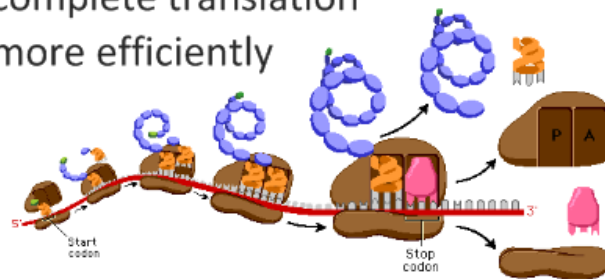
Ribosomes in action:



http://www-class.unl.edu/biochem/gp2/m_biology/animation/gene/gene_a3.html

Polysomes

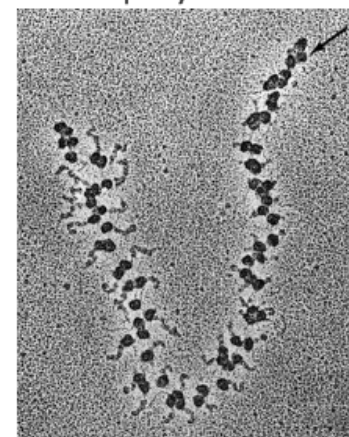
Multiple ribosomes work on the same mRNA at the same time to complete translation more efficiently



http://www.phschool.com/science/biology_place/biocoach/images/translation/polysome.gif

http://nobelprize.org/educational_games/medicine/dna/a/translation/pics_em/polysome.gif

EM of polysome



Translation

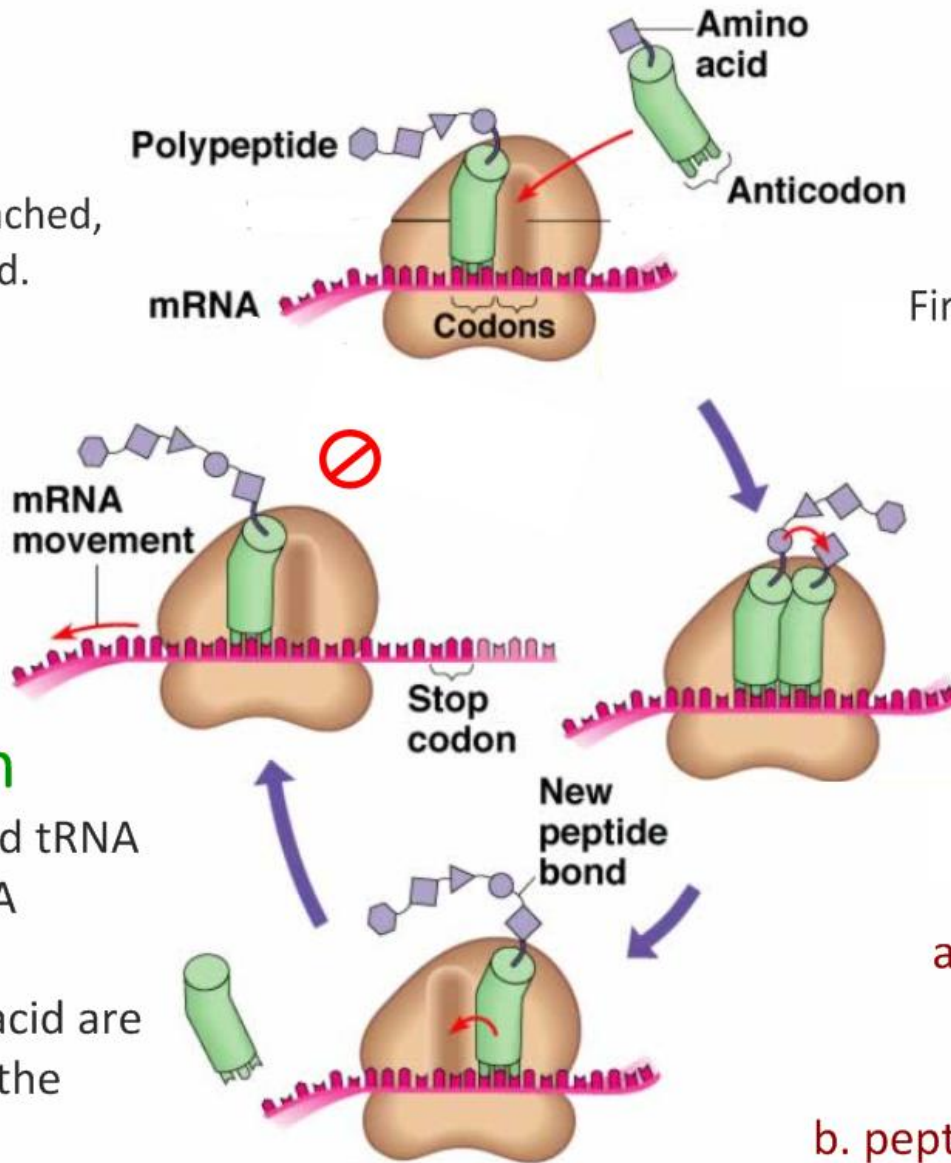
4. Termination

When a **STOP codon** is reached, the polypeptide is released.

Ribosome picks up a new strand of mRNA.

3. Translocation

Ribosome releases used tRNA and moves along mRNA to the next codon. Next tRNA and amino acid are brought in, elongating the polypeptide further.



1. Initiation

Ribosome binds with mRNA at the 'Met' (AUG) codon (Start codon)

First tRNA molecules are brought in.

2. Elongation

Peptide bond is formed between the amino acids, making a polypeptide.

a. codon recognition
tRNA binds

b. peptide bond formation
amino acid added

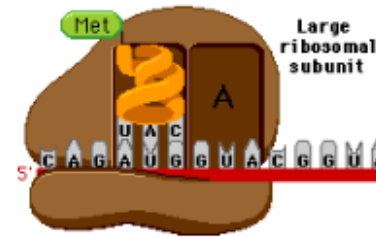
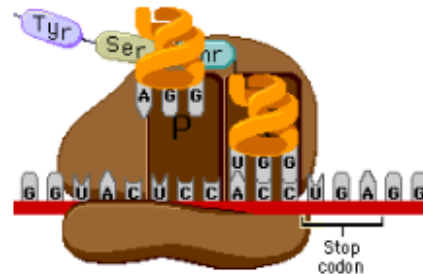


Translation

4. Termination

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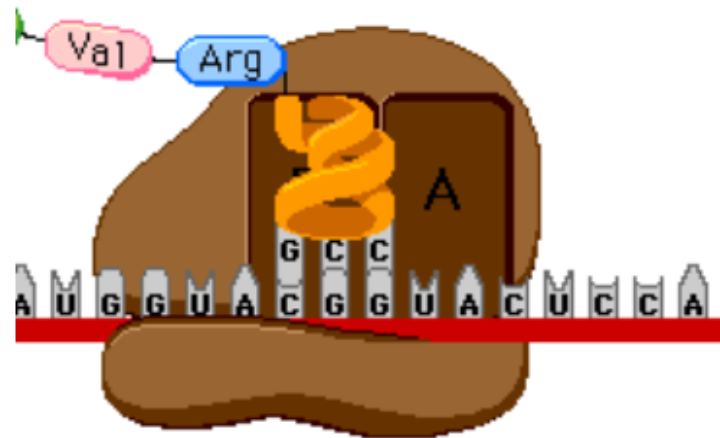
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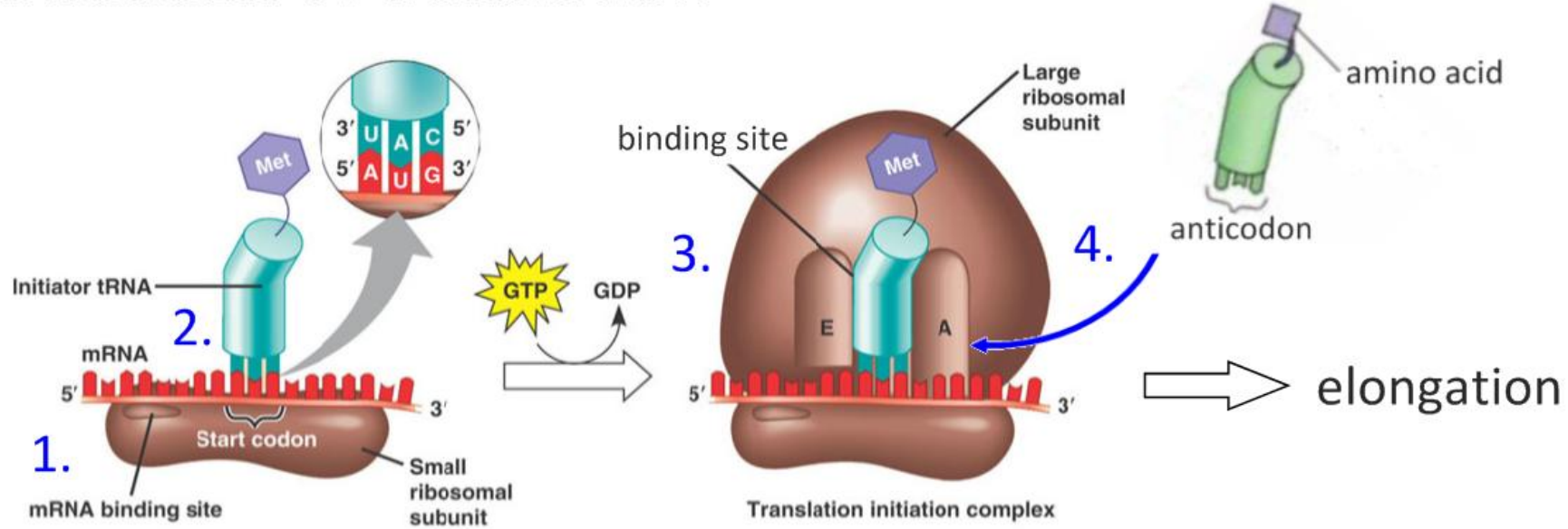
b. peptide bond formation
amino acid added

http://www.phschool.com/science/biology_place/biocoach/translation/intro.html

PEARSON

Click for animations

Initiation of translation



1. mRNA binds to small ribosomal subunit at binding site
2. tRNA carrying 'Met' binds to start codon
3. Large ribosomal subunit attaches
4. tRNA with anticodon corresponding to the next codon attaches
5. Peptide bond forms between amino acids
6. Elongation continues in a 5' - 3' direction along the mRNA

Watch it here:

RNA Translation

- phosphate
- sugar
- A
- U
- G
- C

This mRNA has just emigrated from the cell nucleus to the cytoplasm. It is about to become involved in protein synthesis.

rRNA is replenished from the nucleus as depleted.

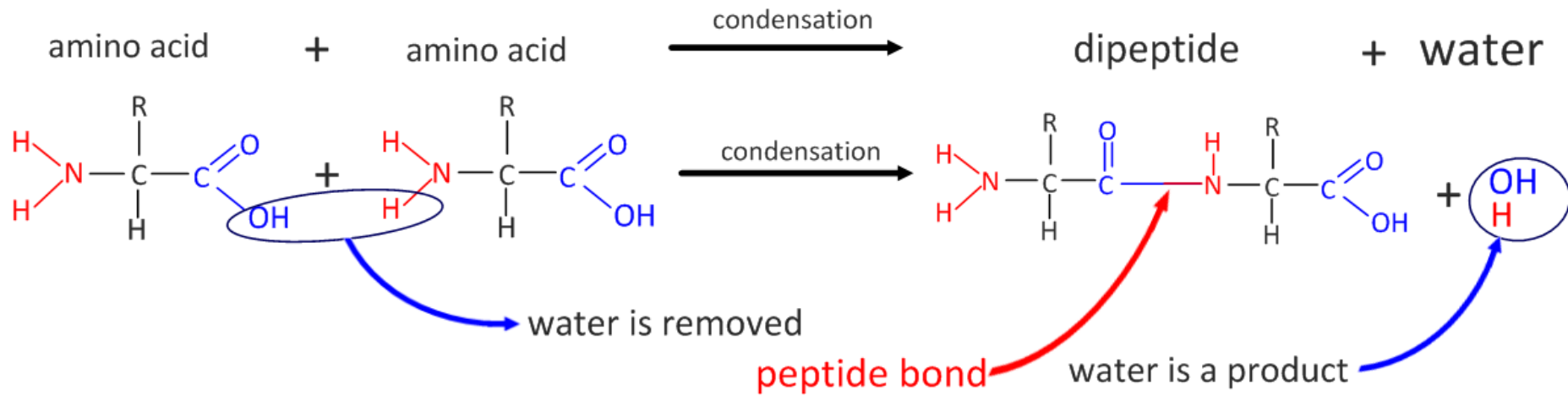
Here are twenty different amino acids, the building blocks of proteins.

Liberation for ribosomal RNA.

The black tick marks separate the individual codon triplets.

http://www-class.unl.edu/biochem/gp2/m_biology/animation/gene/gene_a3.html

Peptide bonds are formed between amino acids:

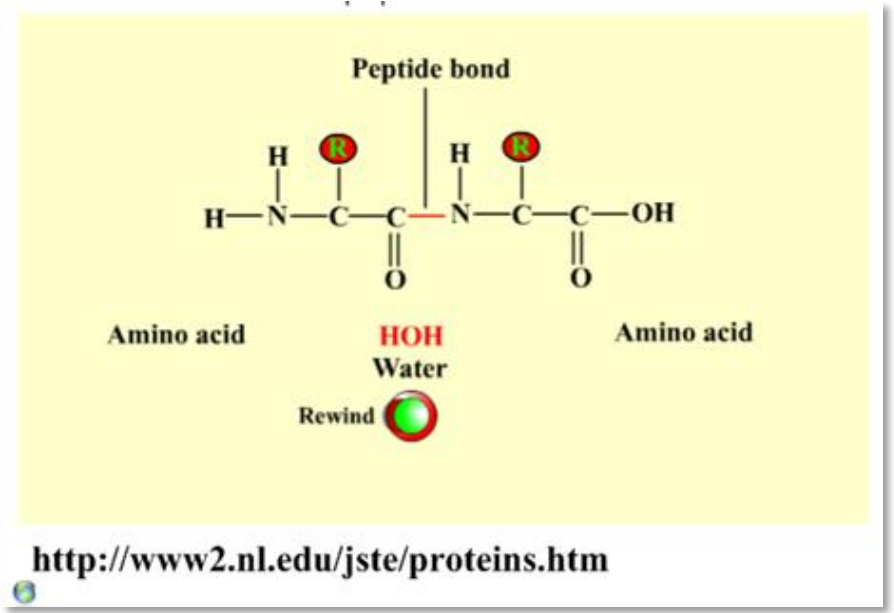


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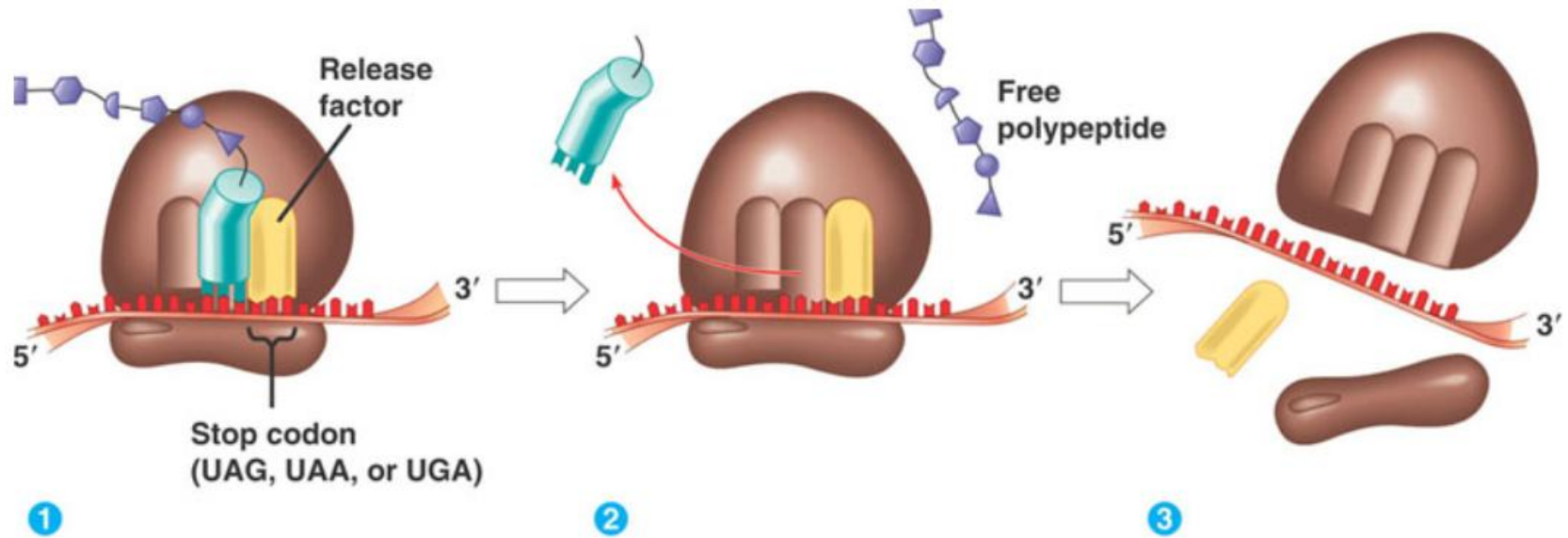
peptide bonds

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

Condensation forms a peptide bond:



Termination of translation



Ribosome reaches the STOP codon

tRNA released to find another amino acid

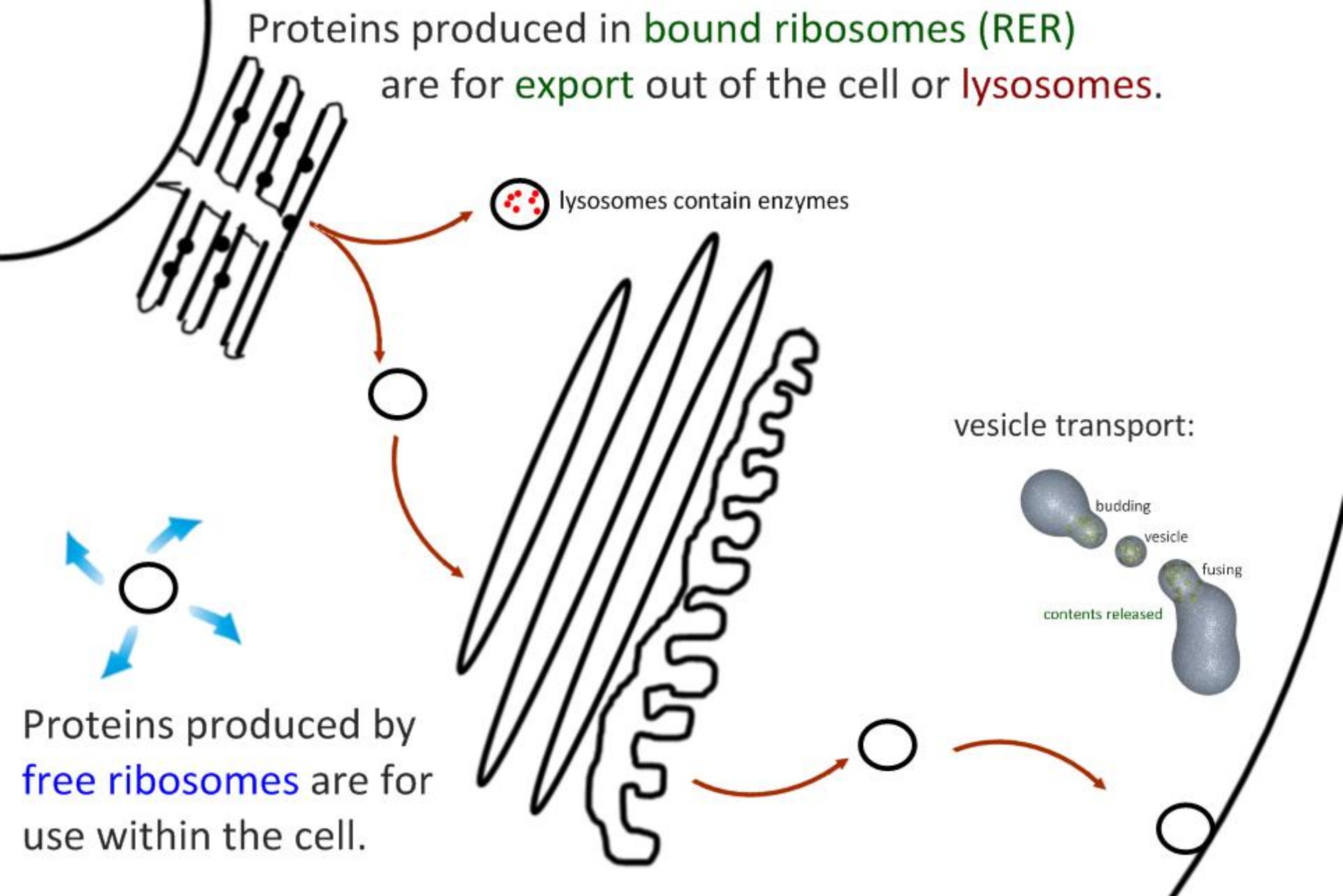
components of the ribosome break apart

Release factor attaches

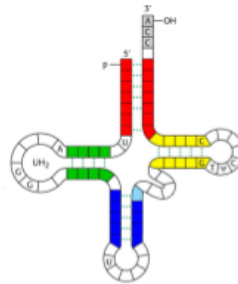
polypeptide released

all are used again

Proteins produced in **bound ribosomes (RER)** are for **export** out of the cell or **lysosomes**.



Proteins produced by **free ribosomes** are for use within the cell.



For more resources and links visit:

<http://sciencevideos.wordpress.com>