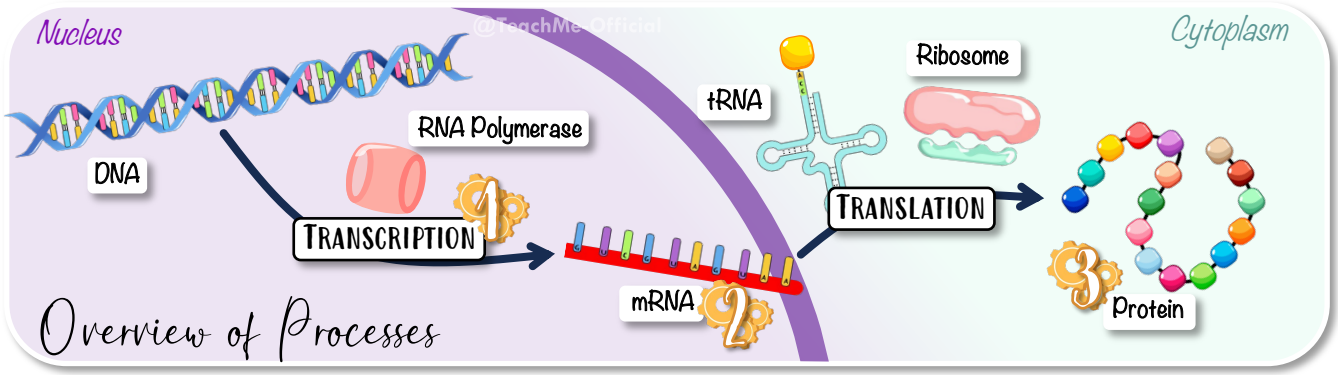
D1.2 Protein Synthesis (HL)

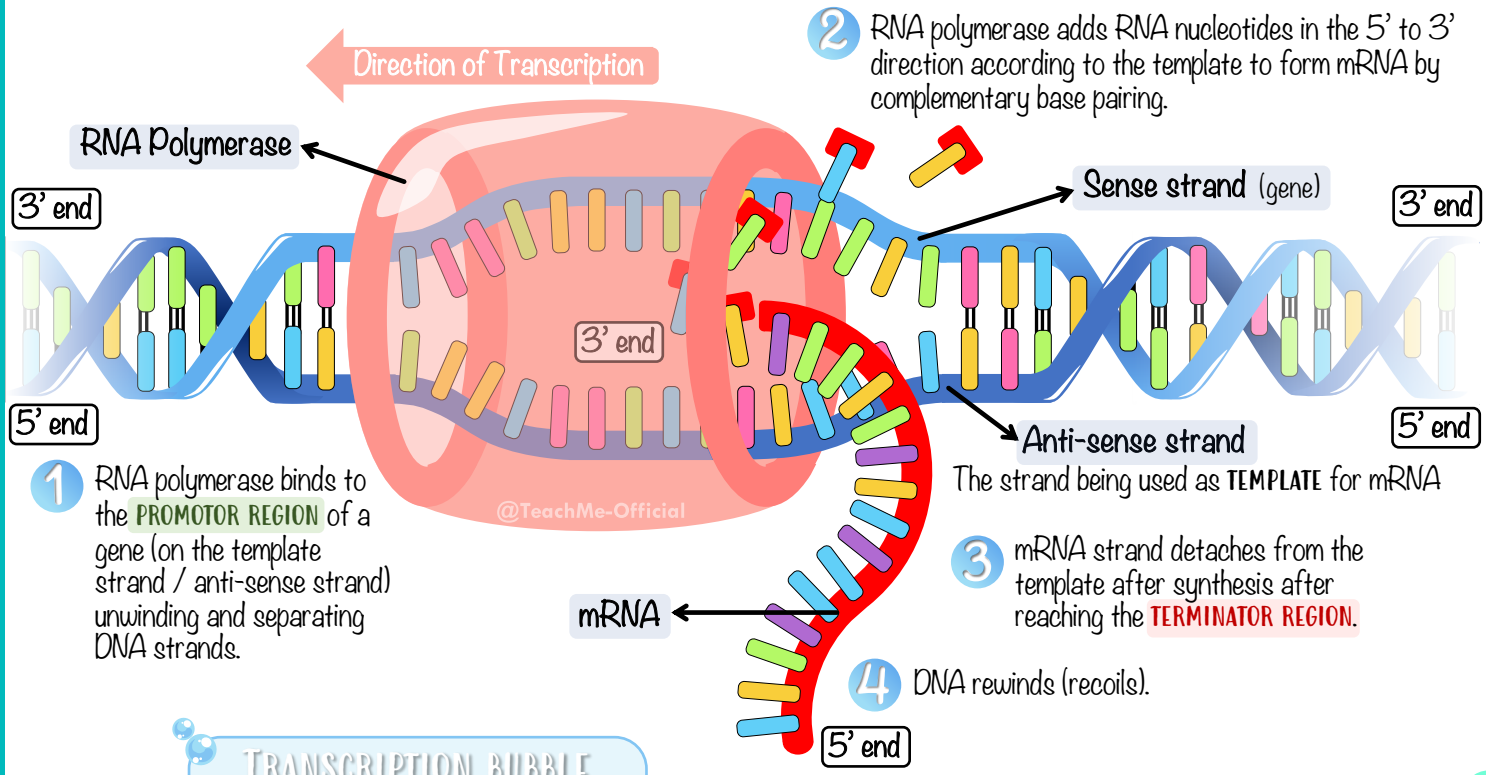
In **HL** we learn some additional details on the processes of transcription and translation and how protein synthesis can be **REGULATED** ( ) at different stages.



1. TRANSCRIPTION

The process of copying a segment (gene) of DNA into mRNA within the **NUCLEUS** of the cell.

Most of the process was learned in section **D1.2 SL**, in **HL** we highlight the **DIRECTIONALITY** (5' to 3') of transcription.



2 RNA polymerase adds RNA nucleotides in the 5' to 3' direction according to the template to form mRNA by complementary base pairing.

1 RNA polymerase binds to the **PROMOTOR REGION** of a gene (on the template strand / anti-sense strand) unwinding and separating DNA strands.

3 mRNA strand detaches from the template after synthesis after reaching the **TERMINATOR REGION.**

4 DNA rewinds (recoils).

TRANSCRIPTION BUBBLE

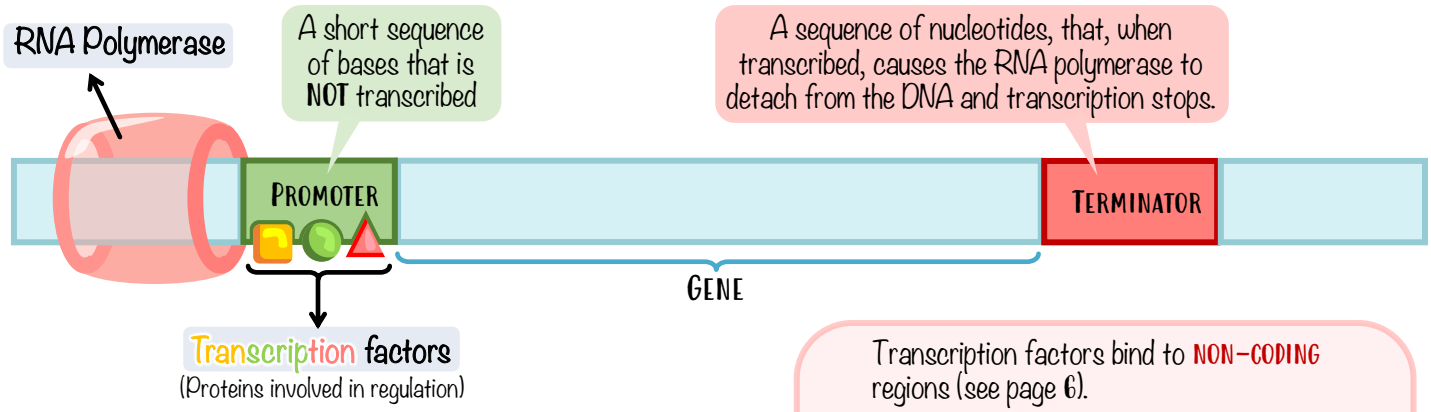
- Template DNA (anti-sense strand)
- Growing mRNA
- RNA polymerase

Protein Synthesis (HL)

1. Control of Gene Expression [Transcription]

[in eukaryotes]

Transcription factors bind to the promotor region, which attract RNA polymerase and transcription begins (transcription bubble).



Transcription factors bind to NON-CODING regions (see page 6).

Some ACTIVATE, some REPRESS a gene

Some attach to the promotor while others attach to a site distant to the promotor region

After RNA polymerase binds, other transcription factors can move into action.

[in prokaryotes]

RNA polymerase attaches to the promotor region of a particular gene and transcription beings. Transcription factors may bind after RNA polymerase to prevent transcription.

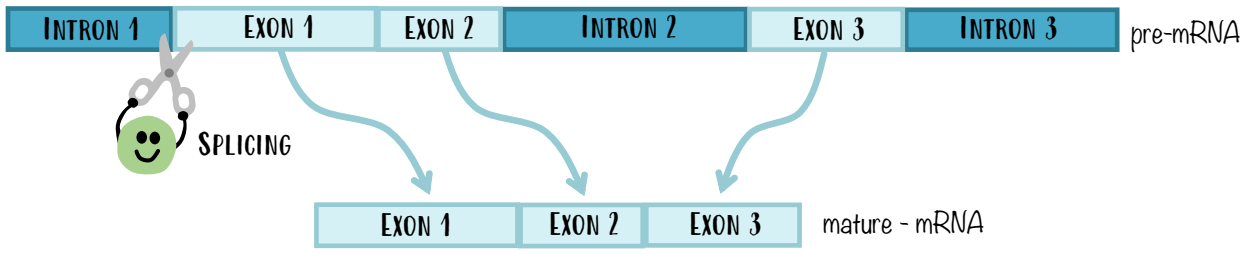
2. Splicing [Post Transcriptional Modification]

Big Brain Tip!

Exons – Expressed
Introns – Intervening

[in eukaryotes]

- Splicing occurs in the NUCLEUS. All the INTRONS (regions which do not code for amino acids) are removed using SPLICEOSOMES.
- Exons (regions that code for amino acids) are kept and later expressed as they form mature mRNA.



Spliceosomes – composed of multiple small nuclear RNAs as well as proteins. They function in the removal of introns from the primary mRNA.

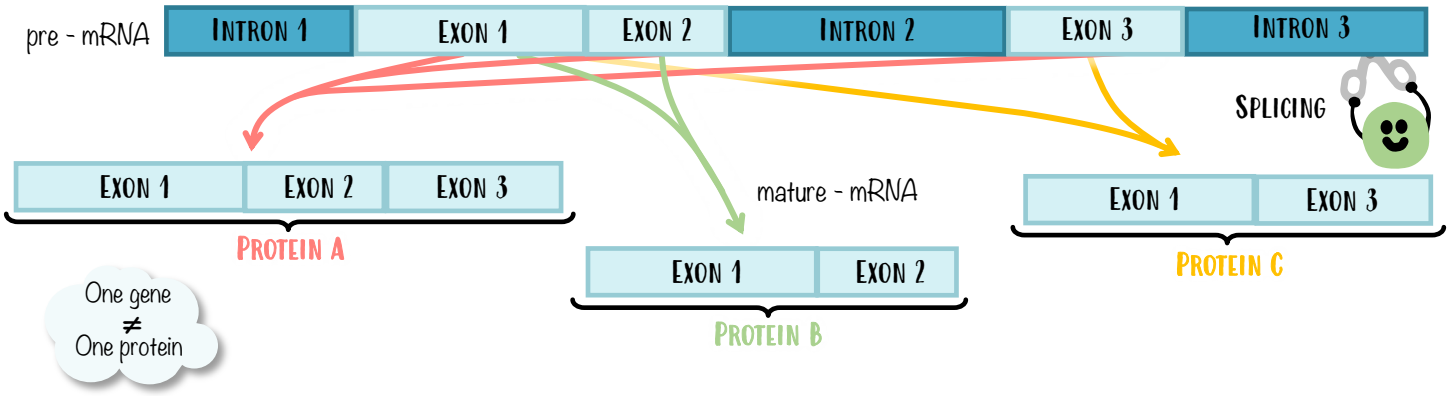
[in prokaryotes]

Prokaryotic mRNA does not contain introns

Protein Synthesis (HL)

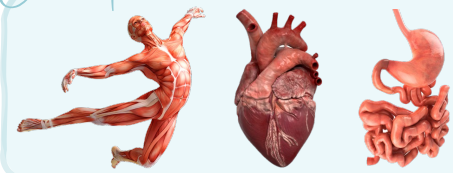
[ALTERNATIVE SPLICING]

Sometimes exons may also be removed. This can create a variation of the final proteins. Multiple "different" proteins can result from a single gene.



Example

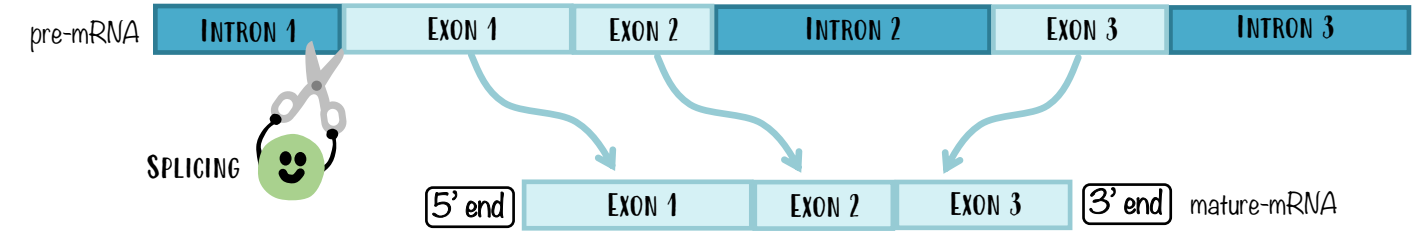
TROPOMYOSIN



Skeletal muscle, cardiac muscle and smooth muscle all contain a different form of tropomyosin as the **TROPOMYOSIN MRNA UNDERGOES ALTERNATIVE SPLICING** which gives slight **VARIATION** in the protein, making it specific for its role in the tissue.

Cap & Poly A tail [POST TRANSCRIPTIONAL MODIFICATION]

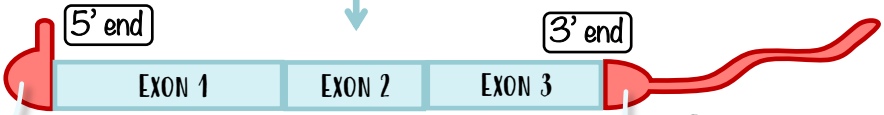
[in both eukaryotes & prokaryotes]



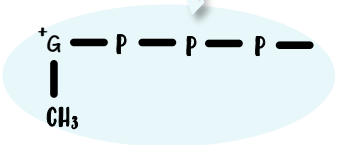
The Cap & Poly A tail;

- Play a role in nuclear export (to exit the nucleus into the cytoplasm)
- Protecting mRNA from being degraded
- Enhance translation (for ribosomes)

Cap (5') + poly A tail (3') are added to the mature mRNA.

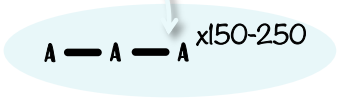


CAP



Made of modified **GUANINE NUCLEOTIDE WITH THREE PHOSPHATES**
Added shortly after the **INITIATION** of transcription.
Recognized by the ribosome to initiate translation.

POLY A TAIL



Poly A tail is made of around **150-250 ADENINE**
Added shortly after the **TERMINATION** of transcription.

Protein Synthesis (HL)

II. TRANSLATION

The process by which the information carried by mRNA is decoded and used to build the sequence of amino acids that eventually forms a protein molecule within the CYTOPLASM of the cell.

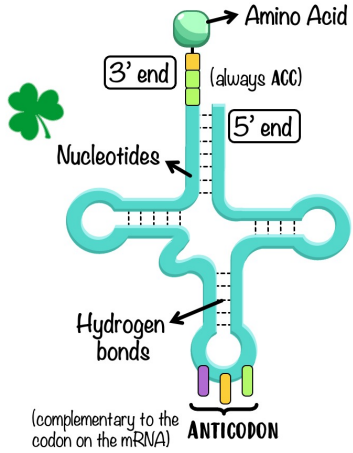
Most of the process was learned in section **D1.2 SL**, in **HL** we highlight the **DIRECTIONALITY** (5' to 3') of translation, the name of different **SITES** on the ribosomes (A, P & E) and more terminology for the **STEPS** of translation (initiation, elongation & termination).

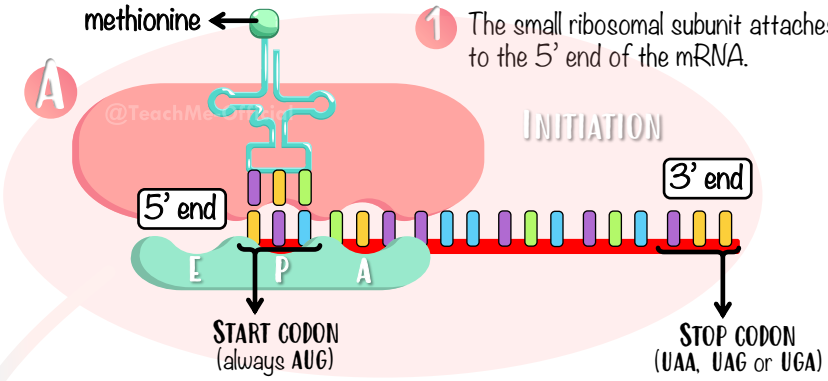
Steps of Translation

A INITIATION → **B** ELONGATION → **C** TERMINATION

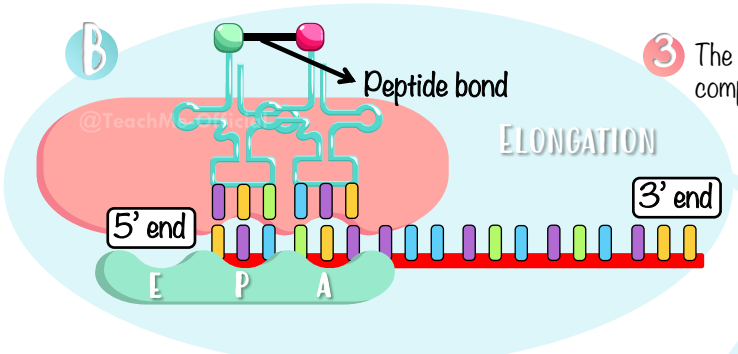
A Holds tRNA carrying the next AA to be added.
P Hold tRNA carrying the growing polypeptide chain.
E Discharges the tRNA that has lost its AA (E = "Exit").

BIG BRAIN TIPS!
Sites on the ribosome spell out "APE"
E SITE is last as it is the Exit

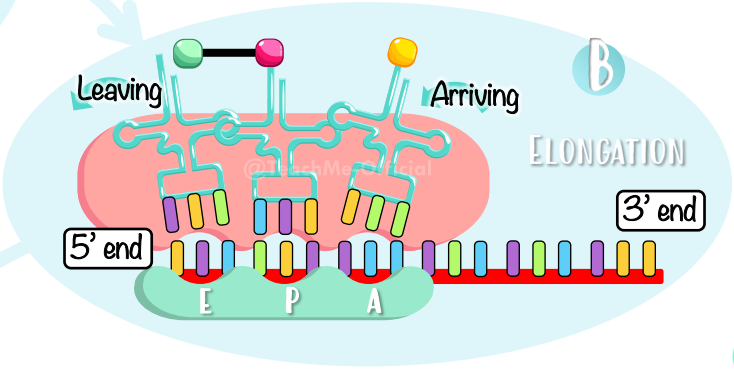




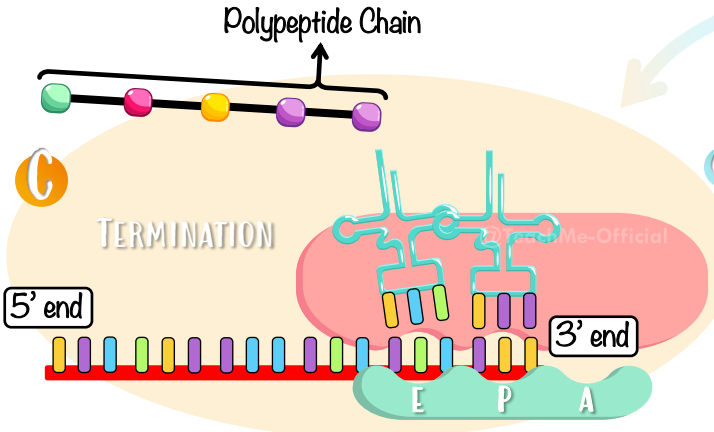
1. The small ribosomal subunit attaches to the 5' end of the mRNA.
2. The initiator tRNA containing methionine (and anti-codon **UAC**) pairs with the to the start **CODON** (**AUG**) at the P SITE.
3. The large subunit of the ribosome is added. The ribosome is now complete: forming the initiation complex.



4. A tRNA carrying the next amino acid binds to the codon forming a **PEPTIDE BOND** between the two amino acids.



5. The ribosome translocates (moves), freeing the A SITE for a new tRNA to bind. The empty tRNA then leaves from the E SITE.
6. This cycle repeats, **ELONGATING** the polypeptide chain.
7. When the ribosome encounters a stop codon (**UAA**, **UAG**, **UGA**), the polypeptide chain is released, and the ribosomal subunits disassemble.



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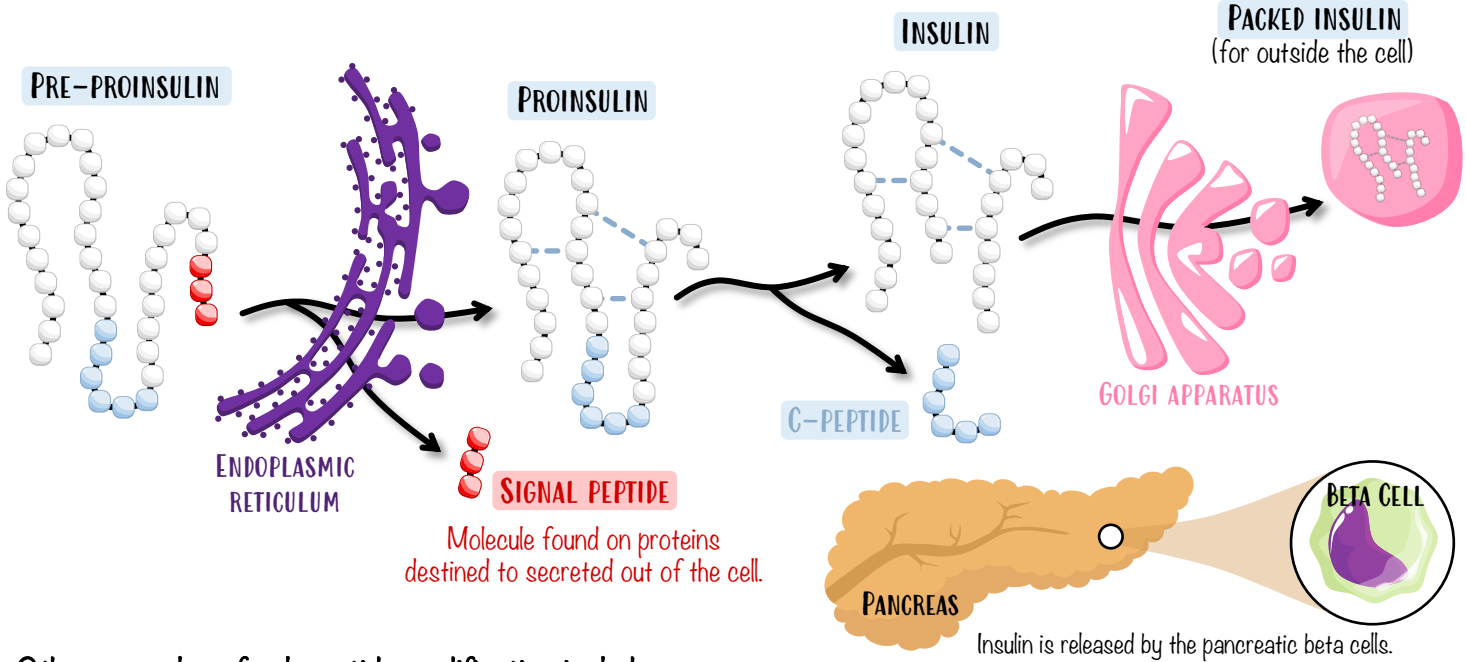
3 Polypeptide Modification [Post-translational]

After transcription and translation, proteins can still be modified to carry out their function. This is illustrated with the example of insulin (a hormone/protein released from the pancreas which increases glucose absorption – causing a decrease in blood glucose).

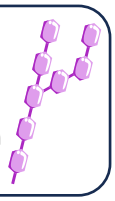


Other examples of polypeptide modification include:

– Chaperones –
These guys play a role with protein folding (shape determines function). provide protection from interfering conditions that hinder folding.

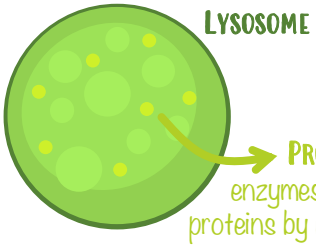
– Disulfide bond formation –
stabilizes tertiary and quaternary structure

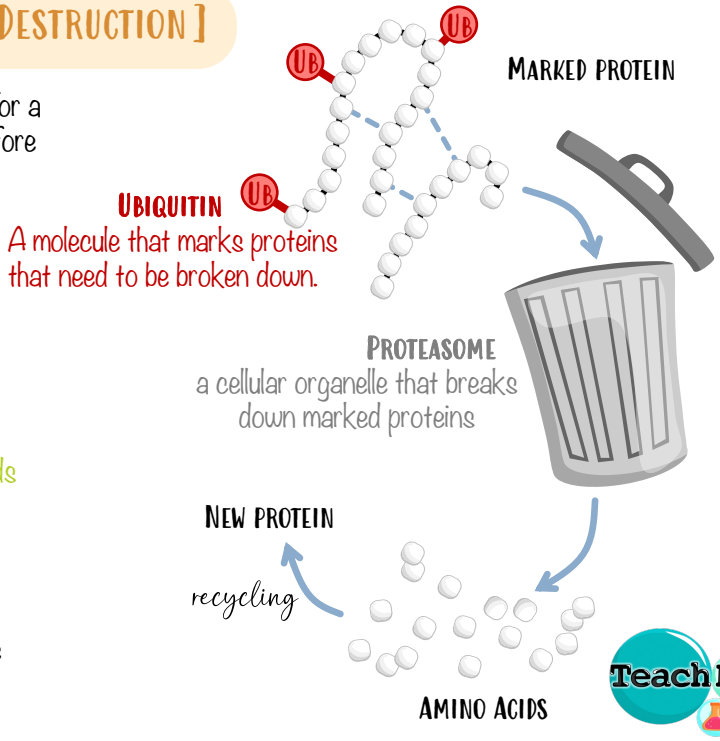
– Glycosylation –
Addition of a carbohydrate side chain to a polypeptide. prevents protein chains from sticking on clumping together. So, they can carry out their function.



3 Recycling of Proteins [Destruction]

The body may wish for a protein to only be capable of acting for a short period of time OR proteins may get damaged (old) therefore mechanisms are in place to get rid of such proteins:



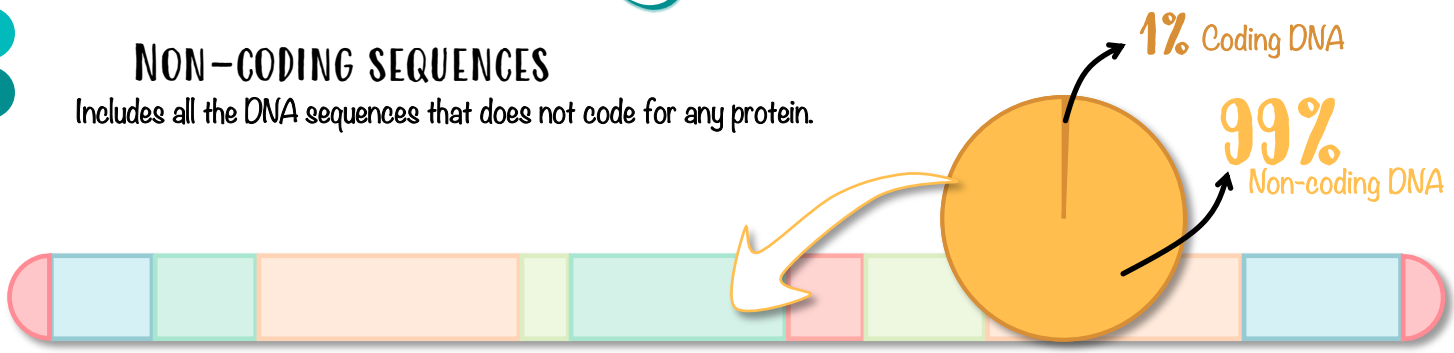


Proteome
the entire set of proteins that is or can be expressed by a cell, tissue or organism.

Protein Synthesis (HL)

Non-coding sequences

Includes all the DNA sequences that does not code for any protein.



Regulators of gene expression

promotors *silencers*

enhancers *insulators*

these influence transcription

tRNA & rRNA

Introns

sections of DNA that are removed from primary mRNA before it leaves the nucleus as mature mRNA

Telomeres

- Found at the end of chromosomes.
- Made of repetitive non-coding DNA sequences.
- Help protect the chromosomes

notes