Translation

Translation or **proteosynthesis** is the translation of a nucleotide sequence of **mRNA** into a sequence of **amino acid** proteins. The process takes place on ribosomes and individual amino acids are arranged according to the rules of the genetic code.

The following are required for translation:

- mRNA;
- tRNA **with bound amino acids from the cytoplasm;**
- ribosome components and proteins conditioning individual reactions (eIF, GTP, ATP, etc.).

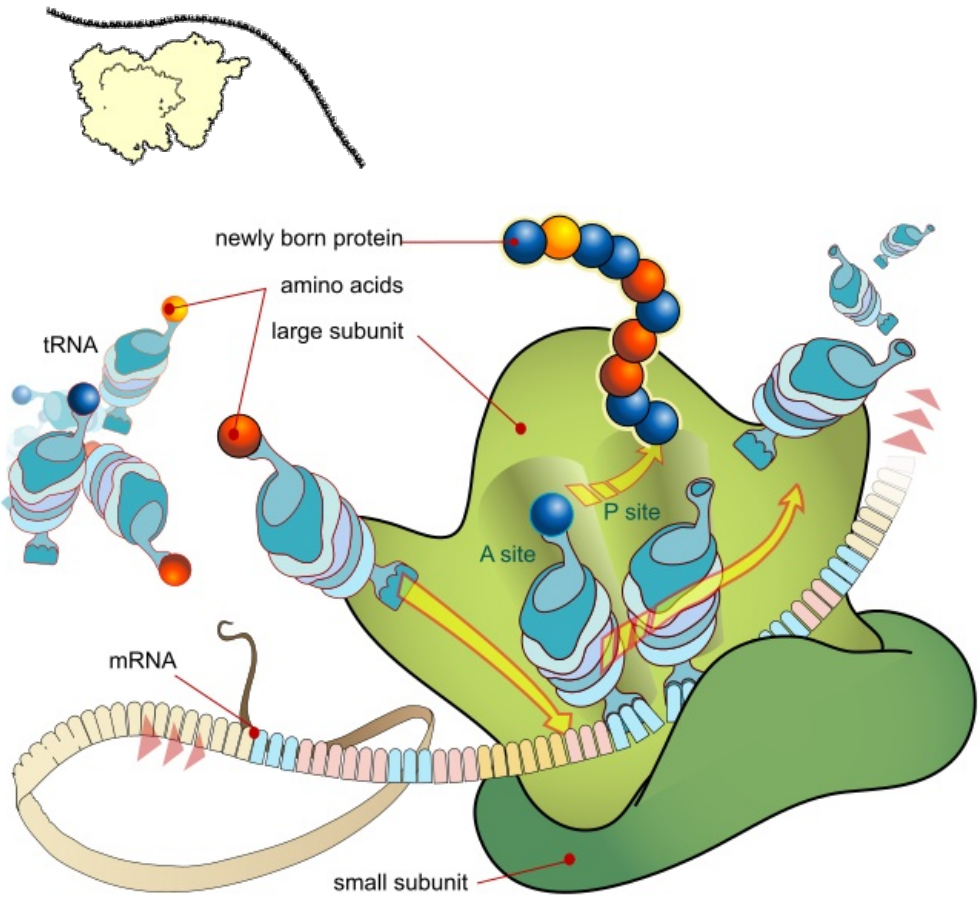
Prokaryotes vs. Eukaryotes

In prokaryotes
: translation **takes place simultaneously with transcription**, i.e. translation is already taking place at one end of the nascent mRNA molecule, while transcription is still continuing at the other.

In eukaryotes
: is produced by transcription of **hnRNA** (pre-mRNA), which is then **post-transcriptionally modified**. The definitive mRNA molecule is transported from the nucleus **to the cytoplasm** using *transport proteins*. Only then do n and parts of the ribosome bind and **translation** begins.

Proteins that are to remain in the cell are created on *free ribosomes*, while proteins are synthesized on the *ribosomes of the endoplasmic reticulum*, which the cell then **transports** into the extracellular space.

Translation Progress



Several Ribosomes are usually attached to one mRNA molecule in a row, so a **polysome is formed**. Under optimal conditions, translation takes place at a rate of up to 40 inserted amino acids per second. Less than 1% of amino acids are misclassified.

Pre-initiation process

- Before translation can begin, amino acids must be activated, for which energy from ATP is used;
- activated AMKs are then attached to the 3'OH end of their tRNA by aminoacyl-tRNA-synthetase enzymes.

Initiation

- In eukaryotes, a number of proteins called **eukaryotic initiation factors** (eIFs, numerically distinguished) are used during translation;
- proteosynthesis (we are only talking about eukaryotes) is initiated by joining:
  - **initiating tRNA** (special tRNA carrying AMK **Methionine**: Met-tRNAiMet);
  - **GTP** (required energy source);
  - **eIF2** (see above) to **the complex**;
- the complex is bound to the small subunit of the **(40S)** ribosome;
- **then, with the participation of other eIFs, the molecule mRNA** is attached to this small ribosome subunit, where its "*cap*" (7-methyl-guanosine) and the attached "*eIF4E and eIF4G*" play an important role *;*
- with the help of the energy obtained by splitting ATP, the mRNA molecule **moves** from the 5' end along the small unit of the ribosome until it encounters the first triplet *AUG* (triplet for **Met**) → there is an **opening of the reading frame** (a mechanism ensuring the reading of information after triplet mRNA bases) and the start of translation;
- the resulting complex is subsequently **connected to the larger subunit** of the ribosome with the help of the energy released by GTP cleavage, and at the same time eIF is released;

  → this is how a **complete ribosome** is formed, where:

  - **Met-tRNAiMet** is located at the *peptide site* (P site).

Elongation

  - The **tRNA** corresponding to the second mRNA triplet is inserted into the *amino acid site* (A site) with the help of elongation factor (EFα) and energy from GTP;
  - on the ribosome, two AMKs are connected to their tRNA at the same time;

- on the ribosome we describe the **P** (protein) site and the **A** (amino acid site) site:
  - **P site** is the binding region for the tRNA *carrying the peptide*;
  - **A site** is the region where the *new tRNA binds with the new AMK*;
- in the beginning, the tRNA carrying the AMK **methionine** gets to the *P site* → with the help of a series of ribosomal peptides, a nucleophilic attack of the amino acid from the A site to the amino acid in the P site of the **peptide bond** occurs between the carboxyl group of methionine and the amino group of the second AMK (the tRNA of this AMK has bound to the A site) → then the **Met is released** from its tRNA and at the same time there is a **transfer of the second AMK** (this AMK is already linked to methionine by a peptide bond) with its tRNA **from A to P** instead → the whole complex **shifts three bases to the 3' end** of the mRNA → to **A** instead, according to the rules of the genetic code, **another tRNA** is included with its AMK.

Termination

- the whole process (codon for mRNA - anticodon for tRNA system) is repeated until a **stop-codon** - **termination codon** is found on the mRNA molecule **(UAA, UAG, UGA);**
- then another protein factor (RF) comes in, which **releases the finished polypeptide** from the ribosomal complex.

Post-translational modifications

In order for the newly **synthesized polypeptide** to become functional, it undergoes a series of modifications:

- a common post-translational modification is the removal of the first **methionine** from the N terminus of the polypeptide
- further e.g. **covalent attachment of chemical groups** and splitting of the **polypeptide**

Chemical modifications of a protein include

- methylation
- phosphorylation
- acetylation
- attachment of larger molecular pods
  - lipids
  - oligosaccharides (glycosylation)

Post-translational modifications are related to the function the protein is supposed to perform

- **glycosylation**
  - typical of proteins that are **secreted from the cell** or transported to lysosomes, the Golgi apparatus, or the plasma membrane
- **lipids**
  - lipid groups are mainly added to **membrane proteins**
  - serves to **anchor** the protein
- **split**
  - during cleavage of the polypeptide there may be **removal of internal peptides** or signal peptides at the N end (methionine)

Proteins that are to be **secreted** (e.g. hormones) or transported to a certain area of the cell (histones to the nucleus, DNA polymerases as well) must be provided with a **certain signal sequence** (signal peptide).

- this signal sequence is called the **leader sequence**, it consists of 15-30 AMK arranged in a **spiral hairpin**
- after **transporting the protein** to the right place, it is cleaved by a special peptidase

Proteins intended for secretion are first transported to the **endoplasmic reticulum** (ER) by the **signal recognition particle** (SRP) - a complex of small cytoplasmic RNAs and proteins

- this complex binds to the **growing polypeptide** and the **ribosome** and via the SRP receptor on the surface of the **rough ER** (docking protein) enters the **ER lumen** and then **out of cell**
- similarly, other proteins are directed to different **target sites** through other **signal sequences** (e.g. nuclear localization signals - transport to the nucleus, lysosomal proteins - transport to the Golgi apparatus and to the lysosome, etc.)

Protein transport

- many of the polypeptides created by the process of proteosynthesis have their application in a **different place** than the place of their creation;
- space **endoplasmic reticulum** is used for transport;
- **co-translational regression** occurs, when at the beginning of translation the signal peptide (containing 15-30 AMK) is conformed into the shape of a spiral hairpin, which is caught in the double layer of the membrane of the **endoplasmic reticulum** (ER) → then the transport is started;
- during further translation, this signal peptide is then separated;
- once it reaches the ER lumen, it is further **modified**;
- translation is controlled by **SRP** (particle recognition signal):
  - it is a complex of 7SL RNA and 6 different proteins;
  - has the ability to **bind** to the ribosome and **stop** further translation until it can come into contact with the so-called **docking protein** that forms part of the membrane ER → thereby frees it from binding to the ribosome and translation can continue.

Links

Related Articles

- Translation in eukaryotes
- Translation in prokaryotes
  - DNA
  - Structure of DNA
  - DNA Replication
- Transcription factors
- Transcription
- Post-transcriptional modifications
- Post-translational modifications
- RNA
  - mRNA

External links

- Translation (Czech Wikipedia)
- Translation (biology) (English Wikipedia)

Source

- ŠTEFÁNEK, George. *Medicine, diseases, studies at the 1st Faculty of Medicine, UK* [online]. [cit. 2010-02-11]. <http://www.stefajir.cz>.

References

- MURRAY, Robert K. – GRANNER, Daryl K. – MAYES, Peter A.. *Harper's Biochemistry.* 23.. edition. Appleton & Lange, 1993. ISBN 0-8385-3562-3.

- ALBERTS, Bruce – JOHNSON, Alexander – LEWIS, Julian. *Molecular Biology of the Cell* [online] . 5.. edition. Garland, 2007. Available from <https://www.ncbi.nlm.nih.gov/books/br.fcgi?book=mboc4>. ISBN 978-0-8153-4111-6.