BIOLOGY

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miso study

01. Translation

During translation, the genetic information present in *m*RNA directs the order of specific amino acid to form a polypeptide chain. The cellular factory responsible for synthesising the protein is ribosome. It consists of structural RNAs and about 80 different proteins. In its inactive state, it exists as two subunits; a large subunit and a small subunit.
When the smaller subunit encounters an *m*RNA, the process of translation of *m*RNA to protein begins. The main steps in translation includes

(i) Activation of amino acids
(ii) Transfer of actinated amino acids to *t*RNA
(iii) Initiation of polypeptide chain synthesis
(iv) Elongation of polypeptide chain
(v) Termination of polypeptide chain formation

(i) Activation of amino acids

The activation of amino acids takes place through their carboxyl groups. In the presence of ATP, each amino acid combines with its specific aminoacyl-*t*RNA synthetase. It produces aminoacyl adenylate enzyme complex. The complete reaction is as follows

$$\text{Amino acid} + \text{ATP} + \underset{\text{Aminoacyl synthetase}}{\text{Enzyme}} \xrightarrow{Mg^{2+}} \underset{\text{Aminoacyl adenylate enzyme complex}}{\text{Enzyme}} - \text{Amino acid} - \text{AMP} + \text{PPi}$$

This step is also known as **aminoacylation of *t*RNA**. The cell has atleast 20 aminoacyl synthetase enzymes for 20 amino acids. Each enzyme is specific and attaches with the specific amino acid without any error.

NOTE ☞ Activating enzymes used are substrate specific, but some activator enzymes can activate more than one3 amino acid, e.g. isoleucine *t*RNA synthetase can also activate valine

(ii) Transfer of Activated Amino Acid to *t*RNA

The amino acid are attached to *t*RNA by high energy bonds. These bonds are formed between the carboxyl group of amino acid and 3′−hydroxy terminal of ribose of terminal adenosine of CCA and of *t*RNA.
The complete reaction is carried out by enzyme synthetase, which has two active sites, i.e. one for *t*RNA and another for specific amino acid molecule. The complete reaction is as follows

$$\underset{\text{Aminoacyl adenylate and enzyme}}{\text{Enzyme—Amino acid—AMP}} + t\text{RNA} \longrightarrow \underset{\text{Aminoacyl } t\text{RNA}}{\text{Amino acid } t\text{RNA}} + \text{AMP} + \text{Enzyme}$$

The aminoacyl *t*RNA moves towards the ribosomes (site of protein synthesis) with *m*RNA.

(iii) **Initiation of Polypeptide Chain Synthesis**

The steps of chain initiation are

(a) Aminoacyl-*t*RNA complex is specific for the initiation codon. The starting amin o acid is methionine (met) in eukaryotes and N-formyl methionine (f-met) in prokaryortes. The activated amino acyl *t*RNA complex attaches to the initiation codon AUG or *m*RNA.

(b) The smaller ribosomal unit (30S or 40S) attaches to *m*RNa to form *m*RNA smaller subunit complex.

(c) The larger subunit then joins this smaller subunit initiation complex to form complete translation initiation complex. Initiation factors are necessary to bring all the components of translation initiation complex together. These factors joins the small subunit of ribosome at the start of the process and leave when large subunit of ribosome joins the small subunit. Mg^{2+} also take part in this process.

(iv) **Elongation of Polypeptide Chain**

The elongation of polypeptide chain involves the following steps

(a) **Codon recognition**

After the formation of complete ribosome (*m*RNA-*t*RNA) complex, an aminoacyl acceptor site (A-site) is established next to the Pi-site. It exposes *m*RNA codon next to the initiation codon. The second amino acid *t*RNA-complex now occupies the A-site of larger ribosomal subunit.

(b) **Peptide bond formation**

First step is followed by the peptide bond formation between both the amino acids present at P-site as well as A-site. The enzyme, which helps in the process of peptide bond formation is peptidyl transferase. Ribosome act as catalyst for peptide bond formation. Bond formation is simultaneous with the transfer of amino acid from P-site to A-site.

(c) **Translocation**

After peptide bond formation, translocation occurs involving the movement of second amino acid *t*RNA-complex from A-site to P-site. In actual sense, this involves the movement of ribosome relative to *m*RNA in $5' \rightarrow 3'$ direction. The initiator *t*RNA molecule is unloaded from the ribosome. As a result of translocation, the P-site becomes vacant and second amino acid *t*RNA-complex along with 'met' or 'f-met' occupies the P-site.

(d) **Growing Polypeptide Chain**

The third amino acid *t*RNA-complex occupies the A-site. This is followed by peptide bond formation, transfer of chain and translocation in the similar manner resulting to a chain of three amino acids.

(v) **Termination of Polypeptide Chain Formation**

Chain elongation continues until a termination codon (UAA, UAG or UGA) reaches the ribosome. Afterwards, the chain terminates and released from the ribosome. This process requires certain Release Factors (i.e. RF-1, RF-2 and RF-3 in prokaryotes and RF in eukarytotes). The process can be simplified as

(a) The termination codon provides signals to the ribosome for the attachment of release factors.

(b) The release factor interacts with peptidyl transferase causing hydrolysis of bond between *t*RNA and nascent polypeptide chain (chain in the process of synthesis). This cause release of polypeptide chain from the ribosome.

(c) Hydrolysis of GTP results in dissociation of release factor from the ribosome. The *t*RNA is also unloaded, ribosomal subunits dissociate and *m*RNA is released.