Energy in Translation

Over the last few years researchers have refined what they know about energy usage in translation. Everyone is relearning this information. Previous handouts, problem sets, exams, and recitation problems may have answers based on outdated knowledge.

This handout is intended to summarize and act as a final guide in this matter.

Two things we need to understand going in:

❶ ATP Equivalents via bond breaking

An "ATP equivalent" is the amount of energy released in breaking a phosphodiester bond in an ATP molecule. For ever bond we break, we get an "ATP equivalent." So for ATP → ADP, we broke one phosphodiester bond and have 1 equivalent. For ATP → AMP, we break one bond initially, but the PP_i that comes off is hydrolyzed to $2P_i$, in effect breaking a second phosophodiester bond, resulting in a net total of 2 ATP equivalents.

❷ GTP = ATP

In the second half of the class you will learn how this works. For now, just know that for every GTP → GDP conversion, we then use one ATP → ADP to recharge the GDP → GTP; essentially, for every GTP used, you've used one ATP.

Step in Translation	Used	ATP Eq.	Multiplication Factor	Step Total
tRNA Charging				
ATP → AMP + PP_i PP_i + H_2O → $2P_i$	1 ATP	2	n amino acids	2n
For aminoacylation, the tRNA utilizes an ATP which has its bonds broken twice.				
Initiation				
IF_2-GTP → IF_2 + GDP	1 GTP	1	1 time only	1
The IF_2-GTP complex is utilized in the binding of the 30S unit top the mRNA				
Elongation				
Delivery of AA by EF-T_u	1 GTP	1	(n-1) amino acids	n-1
EF-T_u is used to escort every amino acid after the fMet, hence the (n-1)				
Displacement of A site to P site	1 GTP	1	(n-1) amino acids	n-1
After the addition of the second a.a., EF-G is used to displace the chain from the A site to the P site. It us used at the end, to allow the RF to bind to the A site.				
Termination				
The release factor RF-3	1 GTP	1	1 time only	1
As was mentioned in lecture 2/26, RF-3 is a EF-Tu homologue and uses GTP				

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Totals: 2n + 1 + (n-1) + (n-1) +1 = 4n

Example: for a 100 a.a. polypeptide.

Step in Translation	Used	ATP Eq.	Multiplication Factor	Step Total
tRNA Charging				
$ATP \rightarrow AMP + PP_i$ $PP_i + H_2O \rightarrow 2P_i$	1 ATP	2	100 amino acids	200
Initiation				
$IF_2\text{-}GTP \rightarrow IF_2 + GDP$	1 GTP	1	1 time only	1
Elongation				
Delivery of AA by EF-T_u	1 GTP	1	99 amino acids	99
Displacement of A site to P site	1 GTP	1	99 amino acids	99
Termination				
The release factor RF-3	1 GTP	1	1 time only	1

Totals: 200 + 1 + 99 + 99 + 1= 400

Proof: 4n = 4 * 100 = 400