Big Protein Synthesis Overview Foldable – Answer Key

What you expect your students to produce will depend on their grade level and their academic level. The detailed information provided in the answer key is to give you a more thorough understanding about this topic. You most likely do not require your students to know all the details, so for your ease of use, highlight which details you would like students to know and use these to guide your lessons.

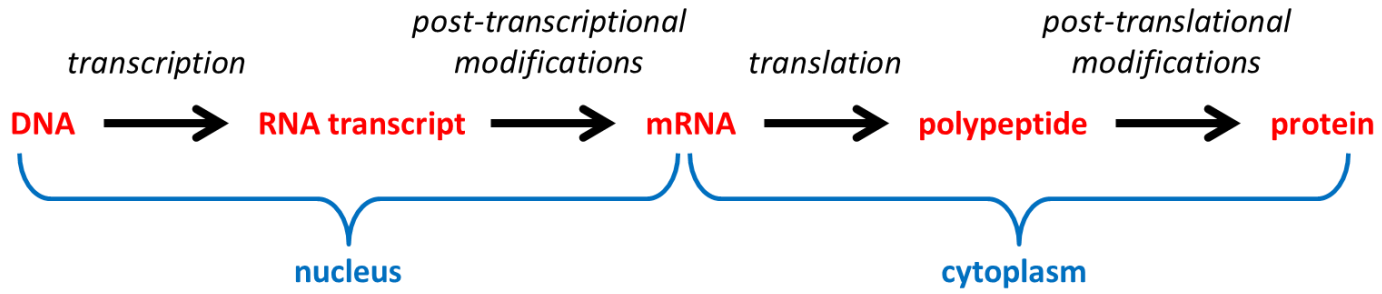
Concepts students should understand first:

1) **DNA contains stretches called genes**. Genes code for the instructions to make polypeptides. Polypeptides form proteins. Polypeptides are made from individual building blocks called amino acids.

2) **mRNA is a copy of a gene in the DNA.** The analogy I like to tell the students is this. "I have a master binder containing all the handouts I will give you throughout the year. I only have one binder containing all of these so it is very precious to me and I never let it leave my possession. When I need you to have a certain handout for a given lesson, I take the original handout out of my binder and make photocopies for each of you in the class to use, then I put the original handout back in the binder. The binder never leaves my sight, but the photocopies of the handouts are free to be taken by you so that you may learn. All of the original handouts make up the entire genome (all the DNA) of an organism. Any given useful handout is a gene. The photocopies are like the mRNA. The students are like the ribosomes. The learning is like the proteins. The binder itself is the nucleus and the rest of the classroom is the cytoplasm. " I usually have great success with this analogy. Try it out! ☺

A nice overview to use before the lesson:

I like to make sure students have this little summary written down somewhere in their notes.



Foldable Notes:

1) **TRANSCRIPTION**

- **STEP 1** of protein synthesis is called **TRANSCRIPTION** and it occurs in the nucleus.
- It involves the creation of RNA from the genes in the DNA.
- This occurs when double stranded DNA opens to expose the **DNA template strand,** which contains the **genes**. Enzymes use the code in the genes to make a piece of RNA which is called the **RNA transcript/primary transcript**. (The RNA transcript is not mature mRNA.) The other DNA strand is called the **DNA coding strand** and does not contain any genes. Recall: Genes contain the genetic information to build polypeptides which turn into proteins.

2) **POST-TRANSCRIPTIONAL MODIFICATIONS**

- **STEP 2** of protein synthesis is called **POST-TRANSCRIPTIONAL MODIFICATIONS** and it occurs in the nucleus. It involves modifying the **RNA transcript** and turning it into functional **mRNA** (messenger RNA). This involves 3 processes:
- **1) Splicing:** This happens by removing the **introns**, which are the non-useful parts of the RNA transcript because they don't code for the polypeptide. After that the **exons**, which are the useful parts of the RNA transcript that code for the polypeptide, are spliced together. Removal of introns and splicing together of exons is done using an enzyme called a spliceosome.
- **2) Capping:** A five prime cap is added to the 5' end of the RNA transcript. This cap is 7-methylguanosine. Its function is to prevent the 5' end of the RNA from being digested by exonucleases in the cytoplasm and it also helps to promote translation.
- **3) Tailing:** A poly-A tail is also added to the 3' end of the RNA transcript. This consists of a stretch of adenosine monophosphates attached to the 3' end. Similar to capping, poly-A tailing helps to protect the 3' end of the mRNA from degradation in the cytoplasm as well as aids with the termination of translation. This is done by an enzyme called poly-A polymerase. Depending on the organism, poly-A tails can be vary lengths from 30 to 250 residues.
- Once splicing, capping and tailing are finished, the mRNA transcript turns into mature mRNA which is ready for export into the cytoplasm through the nuclear pores of the nuclear membrane.

3) **TRANSLATION**

- **STEP 3** of protein synthesis is called **TRANSLATION** and it occurs in the cytoplasm.
- In the cytoplasm, the mRNA encounters ribosomes. When a ribosome attaches to the mRNA this creates the mRNA-ribosome complex and translation can begin.
- In the cytoplasm, tRNA (transfer RNA) attached to amino acids. Each tRNA attaches to its appropriate amino acid to form a structure called an aminoacyl-tRNA (aatRNA). This is done through the actions of an enzyme called aminoacyl-tRNA transferase.
- When a ribosome finds the start codon (AUG) near the 5' end of the mRNA, the ribosome begins to translate (add appropriate amino acids) to form a polypeptide. aatRNAs with anticodons that are complementary the codons on the mRNA will bind to the ribosome.
- The ribosome joins together two adjacent aatRNA by forming peptide bonds between the amino acids. Once a peptide bond is made the tRNA is released back to form another aatRNA in the cytoplasm.
- The ribosome terminates translation when it reaches a stop codon (UAA, UAG or UGA). The ribosome stalls because there isn't an aatRNA made for the stop codon. Stalling allows a release factor to disassemble the mRNA-ribosome complex. The two ribosomal units disassemble and release the mRNA and the polypeptide is released into the cytoplasm for further processing in the next stage.

4) **POST-TRANSLATIONAL MODIFICATIONS**

- **STEP 4** of protein synthesis is called post-translational modifications and it occurs in the cytoplasm. Many polypeptides require these modifications in order to create mature proteins which have the proper 3-D shape (conformation) and function.
- Modifications can involve the following and more:
  1) phosphorylation - addition of phosphate groups
  2) cleavage - removal of certain amino acids
  3) glycosylation - the addition of carbohydrate chains on amino acids
  4) lipidation - the attachment of lipid molecules on amino acids (especially for proteins destined for cell membranes)
  5) formation of disulfide bridges from cysteine residues

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