How Does Protein Expression Work?

Protein expression is a way of creating, modifying, and regulating desired proteins in living organisms. It’s made possible thanks to advancements in biotechnology such as genetic engineering and cloning. Protein expression systems are useful for a variety of reasons, including discovering the intended purpose of various proteins, documenting how they behave outside of normal conditions, and producing pharmaceutical products like antibodies and vaccines. Large-scale operations like enzyme, virus, and vaccine creation require particularly high protein yields, and there’s a wide range of expression systems that can help with this goal. Full protein expression services consist of the expression as well as purification of desired proteins.

Expression vs. Purification

In order to synthesize a target protein, DNA is inscribed in messenger RNA, which will then form the chains that make up protein structure. Typically, expression systems are used to make recombinant proteins or proteins that are cloned from an initial cell. Unlike DNA, which can be reliably replicated with gene synthesis, protein synthesis is a complex process that frequently involves multiple post-translational modification (PTM) processes. Which expression system you'll use for this process depends on the protein you're trying to create, how much of it you'll need, and what you're planning to use it for.

Protein purification is the second major step in the process, and it involves separating the desired protein products from the rest of the cell. This is often done via the process of cell lysis, which is a method of breaking down the cell membrane to expose the inner components. Once the desired protein is extracted, it can then be cleansed of any process-related impurities that may be present. This part of recombinant protein expression can often present the most difficult problems and requires extensive expertise to perform reliably. Below is a basic breakdown of some of the most common expression systems.

Bacterial or Yeast Expression

Single-celled organisms are often used for expression purposes due to their simplicity and fast turnaround. Bacteria cells are especially good for producing vast quantities of proteins easily and cheaply. E. coli is one of the most commonly used because it has several strains that have been specialized for protein expression. There are also many options for expression vectors when it comes to bacterial expression, making it a particularly versatile option.

Yeast expression is frequently used for similar reasons as bacterial expression, but yeast cells are frequently capable of producing more complex proteins than bacteria are. In general, a major downside to single-celled organism expression is that these methods are typically unable to produce particularly complex proteins such as those found in humans.

Insect Expression

Cell expression with insects allows for significantly more complex proteins to be produced with the correct PTMs. Baculovirus expression is frequently used to produce high-level proteins that can’t be made using single-celled organisms. The biggest drawback of this method is that the virus will eventually cause the initial cell to be lysed, thus ending the cloning process. Producing the virus in the first place can be quite time-consuming, and insect cells have more advanced culture needs compared to bacteria and yeast.

Mammalian Expression

Mammalian expression systems are the most complex of all to utilize, but as you’d likely imagine, they also produce the most complex proteins similar to those found in humans. They require the most robust PTMs of any cells, but they allow for more control over exactly when a protein is formed within the cell, which can be extremely helpful for pharmaceutical research. All methods involving mammalian cells also produce high yields of proteins when successful. Mammalian cells do require the most demanding environments, however, and generally require extensive experience to work with.

There are even cell-free systems that can assemble proteins using transcription and translation machinery, though this method requires a great deal of technical knowledge, and it’s expensive compared to any other method.