Synthetic Biology and Protein Engineering: Directed Evolution

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Using the directed evolution method, you can create proteins and enzymes with specific properties for specific purposes in agriculture, industry and medicine. Directed evolution allows you to create these enzymes in a shorter period and it also helps us to understand the enzyme creation process.

What is Evolution? What is Directed Evolution?

To understand directed evolution, it is necessary to first understand evolution. Natural selection, together with a combination of gene-protein interactions, propels evolution. In evolution, certain enzyme functions and enzyme properties are altered, fine-tuned and adapted to the organism's environment. These changes do not work in any particular direction or toward any exact goal, but occur spontaneously in highly specialized forms in response to specific reproduction and survival requirements.

We know this, but we do not know how exactly the interaction processes work. Also, what works well in a cellular environment is not as effective in a non-natural environment for a number of reasons, like substrate insolubility, unstable products or additional chemical reactions. So, natural enzymes that are used in agricultural, medical and industrial applications may not always give reliable results. What are needed are stable enzymes that can stay active for long periods in a non-cellular environment and that can work with a variety of substrates. This is where directed evolution comes in handy.

Directed evolution is a controlled process in synthetic biology that is used to engineer proteins or RNA with certain desirable traits that may or may not be naturally occurring. In this type of protein engineering, scientists work toward a defined goal in a defined way - there may actually be many different ways to reach the defined goal, but researchers chose the one that requires the least effort - and monitor the entire process.

The Directed Evolution Experiment

Directed evolution experiments can be carried out on living cells (in vivo) and also without using living cells (in vitro). One round of experiments typically takes three steps to complete and several experimental rounds are usually necessary to get the proteins or RNA with the required traits.

To begin with, you isolate the genes with the specific traits you want and, using the processes of mutagenesis and/or recombination, create a large library of gene variants; the larger the library the better chance you have of finding gene variants with the required traits. Then the gene variant library is screened to find and isolate the improved gene variants and these are then amplified many times and expressed in bacteria, yeast or any other suitable organism.

In the next round of the experiment, the finally selected gene variant of the previous round is further improved and so it goes on until at last you get the genes with the required traits.

A couple of things to keep in mind about directed evolution -

- Directed evolution cannot usually to any great extent improve traits that are regularly selected for biological functions - you can, however, remove or inhibit these natural traits easily. Ex - high thermostability.
- On the other hand, you can, with directed evolution, effectively improve traits that are not usually naturally selected or required for biological functions - it may be tricky, however, to remove or inhibit these traits. Ex - stability.

Benefits of Directed Evolution

- We can understand how proteins are designed.
- We can create specific proteins and specific enzymes for specific applications.
- We can research and study a vast sequence of possible proteins.

Resources

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http://www.schwaneberg.com/index.php?section=2

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