Chapter 1

Introductory Chapter: Modulating Gene Expression - Abridging the RNAi and CRISPR-Cas9 Technologies

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Additional information is available at the end of the chapter

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1. Gene-silencing technologies over the years

Silencing a gene by deleting it, knocking it down, or simply disabling its function has proven to be a promising tool for understanding the function of the gene and to enable lead optimization during drug development process. In recent times, the two commonly used gene modification methods that have been heavily explored are RNA interference (RNAi) and the revolutionary CRISPR/Cas9 system.

RNA interference (RNAi) is a widely used technology for gene-silencing and has become a critical tool for repression of gene expression which is effectively utilized in various researches. Of late, the mechanism of RNA interference has been well investigated, and undergone various levels of optimization for improving its effectiveness and efficiency.

The clustered regularly interspaced short palindromic repeats (CRISPR)-associated Cas9/gRNA system on the other hand, is a unique, targeted genome-modification technique derived from prokaryotic immune system. The cutting edge research and technology advancements in recent years have enabled the CRISPR-Cas9 system to become a popular tool for introducing heritable, precised, insertions and deletions in the eukaryotic genome.

1.1. Mechanism of the two prominent gene-silencing technologies

The two technologies, however, vastly differ in their mode of action. RNAi uses small interfering RNA molecules to deplete target mRNAs by triggering their degradation and silencing the gene. In RNAi, short, double-stranded RNA molecules, called small interfering RNAs (siRNAs), bind to messenger RNAs (mRNAs) that bear complementary sequences, and blocks the translation of protein encoded by the mRNA. On the other hand, CRISPR/Cas9 system also known as "molecular scissors" can introduce precise and targeted change within the genome.

The technique involves designing specific "single guide RNAs" (sgRNAs) that recognize specific sequences in the genome known as PAM sites. Once the Cas9 proteins along with this sgRNA are introduced into the cells, small deletions occur adjacent to the PAM site via double-stranded DNA breaks. The CRISPR/Cas9 system has been adapted to inhibit the expression of single or multiple genetic loci wherein it cleaves specific DNA sequences, thereby rendering the gene nonfunctional.

1.2. Abridging the two prominent gene-silencing technologies

Although mechanistically different, the two techniques may complement one another very well. Genes can be knocked down with RNA interference (RNAi) or knocked out with CRISPR-Cas9; when used together, they facilitate the discovery and validation of scientific findings. Researchers can do a whole genome RNAi library screen now by using synthetic siRNAs, and then validate each target by designing specific sgRNAs and utilizing the CRISPR-Cas9 technology.

2. Future of these gene-silencing technologies

While the RNAi technique ruled the tailoring of eukaryotic gene expression in the last two decades, the CRISPR/Cas9 system is fairly pretty recent and therefore requires much more exploration and optimization. The superiority of the CRISPR/Cas9 system in effectiveness and efficiency, along with its vast popularity among research community certainly raises the question if in coming years the RNAi technology is going to be obsolete. Application wise, the CRISPR/Cas9 technology truly has the potential to outweigh the RNAi technology, but there is a long road ahead before we can freely make permanent edits to human DNA.

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